

# INSTITUTE & GUILD OF BREWING EXAMINATIONS 2001

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## CHAIRMAN'S REPORT

The pass list and summary statistical details of the 2001 AME and DMB examinations are now published along with the reports of the individual Examiners for each of the papers. Prospective candidates who failed the examinations in 2001 are urged to study these reports.

This report is my fourth and final report as Chairman of the Board of Examiners. Whilst it is pleasing to record the increase in the number of candidates entering the examinations over the last few years, it is disappointing to note that many of the comments related to poor performance continue to recur. In 1998 I wrote 'Familiar themes are present in some of the Examiners' comments; a lack of breadth and depth of knowledge and experience failure to address the question set, poor flow sheets and diagrams.' The same comments apply in 2001. However, it is encouraging to note an overall increase in pass rate for the examinations compared with the 2000 series, particularly in the AME exams, where the average pass rate exceeded 75% compared with 66% in 2000. The pass rate at DMB was 57%, and increase of 5% over the level in 2000. It is pleasing to note the very high quality of some of the AME papers with seven candidates achieving Distinction status. Tracy Hussey of Molson Breweries was awarded the JS Ford Award for the outstanding AME pass. I am particularly delighted to report that for the first time since 1991 the JS Hough Award has been made at DMB level for an excellent set of papers from Yvonne Sinclair of Carlsberg-Tetley. As a student of the late Jim Hough at Birmingham, it is a pleasing conclusion to my final report.

*Dr George Philliskirk*

## INSTITUTE & GUILD OF BREWING EXAMINATIONS 2001

### AME and DMB

The Board of Examiners for the 2001 series of AME and DMB Examinations consisted of the following members:

Dr. G. Philliskirk (Chairman), N. J. Bott (Vice-Chairman), Dr. J. Bryce, Dr. D. Taylor, Prof. C. Webb, Dr. I. Campbell, I. B. Smith, R. F. Illingworth, J. R. Stead, P. K. A. Buttrick, Dr. J. Brown, M. R. Partridge, W. T. Morris, R. Cooper, J. I. C. Robertson.

The Examinations were held in the following world-wide Examination Centres:

#### **UK & Ireland**

Portland Road Pavillion, Edgbaston, Birmingham  
Guinness Learning Centre, Dublin  
New College, Durham, Durham  
Heriot Watt University, Riccarton, Edinburgh  
Guinness Social Club, Park Royal, London  
Interbrew UK Ltd, Magor Brewery, Magor  
Manchester Business School, Manchester

#### **Australia**

NT University, Darwin  
Queensland University of Technology, Brisbane

School of Biological Sciences and Biotechnology,  
Murdoch University, Perth  
University of Melbourne, Melbourne  
University of South Australia, Adelaide  
University of Tasmania, Hobart, Tasmania  
University of Technology, Sydney

**Barbados**

Ministry of Education, Bridgetown, Barbados

**Cameroon**

The British Council, Yaounde

**Canada**

McGill University, Montreal  
University of Calgary, Calgary  
York University, Toronto

**China**

The Education & Technical Building, Shenyang, China

**Ghana**

The British Council, Accra

**India**

The British Council, Chennai (formerly Madras)  
The British Council, Mumbai (formerly Bombay)

**Jamaica**

University of West Indies, Kingston

**Japan**

Tonegawa Brewery, Ohra-gun, Gunma-ken, Japan

**Kenya**

University of Nairobi, Nairobi

**New Zealand**

Auckland University of Technology, Northcote, Auckland  
Christchurch Polytechnic, Christchurch

**Nigeria**

The British Council, Lagos

**Papua New Guinea**

University of Papua New Guinea, Papua New Guinea

**Romania**

Dreher Breweries, Budapest

**South Africa**

SAB Prospecton Brewery, Durban  
SAB Technical Training Institute, Rivonia, Johannesburg  
The Yardstick, Ibhayi Brewery, Port Elizabeth  
University of Cape Town, Cape Town

**The Netherlands**

Heineken, Zoeterwoude

**Trinidad**

Carib Brewery, Champs Fleurs, Trinidad

**Uganda**

The YWCA, Kampala

**USA**

Sudwerk Brewpub (UC Davis), Davis  
University of Wisconsin, Mellencamp Hall, Milwaukee

**Zimbabwe**

University of Zimbabwe, Mount Pleasant, Harare

**Results of AME (including distilling) and DMB**

Four hundred and seventy-five candidates sat part or all of the Institute's Examinations (445 in 2000), at 41 (51 in 2000) centres around the world.

One hundred and twelve candidates sat part or all of the DMB. Fifteen candidates accumulated passes in all modules and thus qualified as Diploma Members.

Three hundred and fifty-one candidates sat part or all of the AME. One hundred and five candidates accumulated passes in all modules, and thus qualified as Associate Members.

Fourteen candidates sat part or all of the AME in Distilling. Two candidates accumulated passes in all modules and thus qualified as Associate Members.

The number of candidates who sat each module of the AME and DMB is as follows:

AME Module 1, 199 candidates (188 in 2000)  
AME Module 2, 167 candidates (157 in 2000)  
AME Module 3, 139 candidates (127 in 2000)  
AME Distilling Module 1, 7 candidates (5 in 2000)  
AME Distilling Module 2, 5 candidates (5 in 2000)  
AME Distilling Module 3, 3 candidates (7 in 2000)  
DMB Module 1, 37 candidates (44 in 2000)  
DMB Module 2, 36 candidates (36 in 2000)  
DMB Module 3, 47 candidates (32 in 2000)  
DMB Module 4, 34 candidates (27 in 2000)  
DMB Case Study, 38 candidates (28 in 2000)

The statistics for the number of candidates who sat the IGB Examinations are as given below.

	UK and Ireland	Overseas
Total number of AME candidates – 351	117 33%	234 67%
Total number of AME distilling candidates – 14	11 (Edinburgh) 73%	3 (Uganda) 27%
Total number of DMB candidates – 112	57 51%	55 49%

The successful candidates from the 2001 Examinations, who meet all IGB criteria, are listed as follows.

**Diploma Master Brewer Examination**

**DMB module one - passes**

Biss, Christopher	Africa
Bradford, M. Ian	Midland
Brown, Russell Daniel	Great Northern
Burn, Ian	Great Northern
Chettiar, Sothipragasan	Africa
Chilton, David James	Midland
Chisholm, Christopher Brian	Great Northern
Feasey, Paul Robert	Irish
Fletcher, Michael William	International
Gosling, Russell Michael	Southern
Gulliver, Marie Kathryn	Great Northern
Haywood, Richard John	Midland
Healy, Shane Martin	Irish
Hobbs, Martin Charles	Great Northern
Kalule, Joseph	Africa
Kobia, Athanasius	Africa
Kuzela, Robert	International
MacDonald, Hector F.	Scottish
Monteiro, Antonio J. M.	Southern
Odendaal, Johan Danie	Africa
Peters, Ann Margaret	Southern
Pillay, Poovalingam	Africa

Ramarumo, Phoko Maurice	Africa	Hamilton, Andrew ++	Great Northern
Salisbury, Helen Claire	Great Northern	Hewitt, Jayne L.	Great Northern
Young, Georgina Margaret	Southern	Hollin, David Russell ++	Southern

**DMB module two - passes**

Adadevoh, Eric Sewonu	Africa
Appiah-Danquah, Martin	Southern
Chilton, David James	Midland
Deakin, Christopher Ronald	Midland
Edwards, Geoffrey ++	Asia Pacific
Ejiofor, Sylvester N.	Africa
Feasey, Paul Robert	Irish
Fleming, Shona	Africa
Gittens, Steven Patrick Clifford	International
Gopalakrishnan, K. N.	Asia Pacific
Heasman, Toby Andrew	Midland
Horn, John D.	Africa
Kalule, Joseph	Africa
Katorobo, Edward M.	Africa
Knops, Robert	Scottish
Liddell, Robin	Southern
Mitchell, Andrew Stanley	Africa
Muiruri, Jane M	Africa
Ogbedeh, Anselm O. C.	Africa
Ramarumo, Phoko Maurice	Africa
Sinclair, Yvonne ++	Midland
Summerskill, Andrew David	Southern
Tamilarasan, Arumugam	Asia Pacific
Toft, Michael N.	Midland

**DMB module three - passes**

Acom, Agnes	Africa
Bain, Fiona Claire ++	Scottish
Brimble, Timothy John	Midland
Bromley, Ruth Helen	Great Northern
Brooks, Martin D. ++	Africa
Brown, Russell Daniel	Great Northern
Chilton, David James	Midland
Clarke, David James ++	Great Northern
Curtis, Stephen M ++	Southern
Douglas, Phillip Anthony	Midland
Erhagbe, Christopher Umole	Africa
Fleming, Shona	Africa
Forbes, Ian Anthony John ++	International
Liddell, Robin	Southern
Markham, Frank Anthony	Great Northern
Ramarumo, Phoko Maurice	Africa
Rushe, Brendan Thomas G. ++	Irish
Sinclair, Yvonne ++	Midland
Stainthorpe, Christopher James	Midland
Tchuitio, Ndjila Jean Paul	Africa
Walton, Maurice	Midland

**DMB module four - passes**

Bain, Fiona Claire ++	Scottish
Bromley, Ruth Helen	Great Northern
Brooks, Martin D. ++	Africa
Curd, Jeffrey P. R. ++	Southern
Curtis, Stephen M. ++	Southern
Dowd, Paul	Africa
Fielding, Stephen ++	Asia Pacific

Hollin, David Russell ++	Southern
Kamdem, Alain Rousseau	Africa
Okereke, Chinedum A. ++	Africa
Ramarumo, Phoko Maurice	Africa
Runcie, Andrew Lawrence	Scottish
Shieldon, Robert A.	Midland
White, Roderick Ian	Midland
Yalaju, Mark E.	Africa

**DMB case study - passes**

Acom, Agnes	Africa
Bain, Fiona Claire ++	Scottish
Brooks, Martin D. ++	Africa
Callan, Matthew John ++	Midland
Chilton, David James	Midland
Clarke, David James ++	Great Northern
Curd, Jeffrey P. R. ++	Southern
Curtis, Stephen M. ++	Southern
Dobner, Mark A.	Southern
Douglas, Phillip Anthony	Midland
Erhagbe, Christopher Umole	Africa
Fielding, Stephen ++	Asia Pacific
Forbes, Ian Anthony John ++	International
Grobbelaar, Albert Stefanus	Africa
Haywood, Richard John	Midland
Jama, Idris	Midland
Monteiro, Antonio J. M.	Southern
Mungai, Jonathan Njenga	Africa
Ryman, Roger John	Scottish
Shieldon, Robert A.	Midland
Sinclair, Yvonne ++	Midland
Walton, Maurice	Midland
White, Roderick Ian ++	Midland

**Associate Membership Examination – 2001 passes (modules one, two and three)**

Alatorre, Bernardo *	International
Beauchemin, Renee Claude	International
Bouchard-Marchand, Edith	International
Buggey, Lesley Ann	Southern
Cele, Thokozani	Africa
Chatterjee, Jaydeep	Asia Pacific
Engelbrecht, Pieter *	Africa
Feiner, Frederik Walter Jacobus	International
Garegae, Enoch Boineelo	Africa
Golson, Daniel B.	International
Hayes, Brooks *	International
Hook, Matthew	International
Hussey, Tracy Colette **	International
Ison, Nicholas E.	International
Johnson, Axel	International
Kanyaruguru, Deo Busingye	Africa
Kapp, Gregory Richard	International
Kasanka, Paul Chris	Africa
Kaziba, Richard	Africa
Kessels, Henk	International
Kiyangi, Stephen	Africa
Kochl, Martin	International
Komada, Tohru	International

Lalobo, Clement E.	Africa	Jones, Ian	International
Lavery, Sean J.	International	Jontef, Michael Peter	Asia Pacific
Lindell, Jonathon H.	International	Kennedy, Lynda Michelle	Asia Pacific
Lindsay, Donald	International	Kibalama, Patrick +	Africa
Long, Marvin James	Africa	Mackintosh, Peter Lachlan	Asia Pacific
Mateeba, Tim	Africa	Mackrell, Stewart Douglas	Africa
Mbogo, George	Africa	Markin, Samuel Yankah	Africa
Mckean, David T.	International	Marshall, Richard Brian	Great Northern
Moloto, Lebogang	Africa	Martin, Calvin	Africa
Morse, Jonathan Carey	International	Mason, Bret	International
Murfin, Patrick	International	McCartney, Errol Peter	International
Musisi, Moses Lubega	Africa	Merange, Graham Frank	Asia Pacific
Mxenge, Nothemba *	Africa	Mgabadeli, Xolile Neville	Africa
O'Leary, Brian Liam	Asia Pacific	Mickelson, Leon James	Asia Pacific
Ongora, Isaac	Africa	Mitchell, Kevin Raymond	Asia Pacific
Oryniak, Carla	International	Mkaruka, Renatus Kaitira Malembo	Africa
Paquette, Christian	International	Mkemangwa, Dominic Galiusa	Africa
Sands, David	International	Mkhwanazi, Penelope	Africa
Scholl, Kristopher *	International	Morton, Amanda Jane	Great Northern
Scull, Jason	International	Nelson, Mark	International
Slade, Gregory Keith	Africa	Nischwitz, Ralph	Asia Pacific
Smits, Elien Clara	International	O'Connor, Cam A.	International
Swanepoel, Shona Dianne	Africa	O'Dea, Henry Michael James	Irish
Tonussi, Tom T. *	International	Pearson, Kevin John	Midland
Van Hee, Koen	International	Purkiss, Emily Jane	Asia Pacific
Vvuko, William Luga	Africa	Ragbir, Akash +	International
Ward, Robert Edwin	International	Ramachandran, Mallaiah	Asia Pacific
Whiteley, Andrew John	Southern	Ramshaw, James Edward Michael	Midland
Williams, George A.	International	Seward, Samuel Thomas	Asia Pacific
Yarrington, David	International	Smith, Laura Ann +	Asia Pacific

**AME module one - passes**

Akker, Caroline	Midland
Alobwede, Metuge Charles	Africa
Anderson, Claire	Great Northern
Aspin, Dave	Great Northern
Baker, Steven James	Great Northern
Bentley, Richard Stuart	Great Northern
Benzaquen, Mark Joseph	International
Bihl, Georgia Gladys	Africa
Botha, Bruce Paul	Africa
Bowen, Robert John	Southern
Challenger, Roy James	Asia Pacific
Chapman, Stephen Leslie	Great Northern
Cole, Neil W.	Asia Pacific
Cooper, Zoe	Midland
Crawshaw, Jonathan	International
Dahms, Carl Michael	Asia Pacific
Delaere, Sean Albert	Asia Pacific
Den Broeder, Remi	International
Ekpo, Emmanuel Sampson	Africa
Ellis, Richard Warren	International
Eltagouri, Mustafa	Midland
Frederickson, Jason R.	International
Gardner, Ronald +	Great Northern
Gatt, Christopher Peter	Asia Pacific
Gostelow, Helen Elizabeth	Midland
Graves, Ian Roy	Asia Pacific
Greening, David James +	Midland
Harbottle, Brett Cameron	Asia Pacific
Ivkovic, Dalibor	Asia Pacific

Soti, Stephen Martin	International
Sowerby, Natalie	Asia Pacific
Stephens, Jeremy Matthew	Southern
Stevens, Gary Paul	Southern
Stradiotto, Steven	International
Taylor, Robert A.	International
Too, Robert Kibiego	Africa
Tucker, Wayne Alexander	Asia Pacific
Van Der Vyver, Paul	Africa
Villadelgado, Evangeline	Asia Pacific
Vote, Shannon Patricia	Asia Pacific
Weaver, Anne Louise	Asia Pacific
Weir, Margaret	Asia Pacific
Willcox, Sarah	Great Northern
Wilson, Ross Andrew	Asia Pacific
Young, Conor +	Irish

**AME module two - passes**

Adesida, Bolade A.	Southern
Allan, David John	Scottish
Alobwede, Metuge Charles	Africa
Ashmore, Michael Andrew	Midland
Baker, Steven James	Great Northern
Bamidele, Olumide Titilayo +	Africa
Barker, Belinda Jayne	Midland
Bentley, Richard Stuart	Great Northern
Bihl, Georgia Gladys	Africa
Bowering, David +	Midland
Brawley, Gerry	Great Northern
Brogan, Gavin James	Irish

Burns, Bradley	Great Northern	Okpanefe, Willie Ojewve	Africa
Buzigi, Simon A. +	Africa	Ragbir, Akash +	International
Byrne, John M. P. +	Irish	Scott, Ian	Southern
Caldwell, Bronwyn Margaret	Asia Pacific	Smyth, Audrey	Southern
Callaghan, Martin Peter	Irish	Stephens, Jeremy Matthew	Southern
Chesterman, Miles Robert William	Southern	Tailby, Janet E.	Southern
Chou, Phillip K.	International	Too, Robert Kibiego	Africa
Colfer, Stephen Barry	Irish	Watts, Emma Louise +	Southern
Crawley, Bernard	Irish	Weaver, Anne Louise	Asia Pacific
Cremin, Dave Francis	Irish	Wicomb, Lynn Raye	Africa
Dalton, Joseph	Irish	Williams, Marco Lester	Africa
De Burca, Diarmaid	Africa	Woodcock, Deborah Jane	Southern
De Vries, Harro Maxim	International	Young, Conor +	Irish
Den Broeder, Remi	International		
Du Plessis, Claire Natalie	Africa	<b>AME module three - passes</b>	
Ellam, Steven	Great Northern	Amoforitse, Samuel Chuks	Africa
Erasmus, Johan Anton	Africa	Balikagira, Alfred +	Africa
Fantin, Luigi +	International	Ball, Philip John	Great Northern
Fitzgerald, David John +	Irish	Belcher, Clive	Africa
Flanagan, Brendan Gerard	Asia Pacific	Bennett, Sean Christopher +	Southern
Fowler, Paul Russell	Great Northern	Besiime, Emmanuel	Africa
Francis, Patrick	Asia Pacific	Brennan, Martin +	Southern
Frederickson, Jason R	International	Brogan, Gavin James	Irish
Furey, Brian Joseph	Irish	Buzigi, Simon A. +	Africa
Gallimore, Paul	Midland	Chou, Phillip K.	International
Groeneveld, Steven Craig +	Africa	Croker, Jenna Catherine +	Southern
Hobbs, Andrew	Great Northern	Cuders, David John +	Great Northern
Igenegbai, Francis Erua	Africa	Daly, Brian Patrick +	Irish
Impey, Michael Martin +	Irish	De Burca, Diarmaid	Africa
Kalyana Sundaram, K.	Asia Pacific	De Vries, Harro Maxim	International
Kasiga, Gilman Stephen	Africa	Eijkman, Johan Folkert	International
Kavanagh, Michael Thomas	Irish	Fitzgerald, Fergus Richard +	Southern
Kenny, Siobhan	Southern	Ganesh Ramu, A.V. +	Asia Pacific
Kentish-Barnes, Edward	Southern	Greening, David James +	Midland
Khumalo, Funeka Nomasundu +	Africa	Groeneveld, Steven Craig +	Africa
Kibalama, Patrick +	Africa	Ireland, Richard Arthur John +	Scottish
Krey, Karen	International	Kakuba, Andrew +	Africa
Lawlor, Gerard Thomas +	Irish	Kapngeywo, Kaps	Africa
Marafioti, Anthony Domenic	Asia Pacific	Khumalo, Funeka Nomasundu +	Africa
Markin, Samuel Yankah	Africa	Kiggundu, Harrison +	Africa
Martin, Calvin	Africa	Kyte, Philip Jeremy +	Southern
Martin, Henry Korgis	Asia Pacific	Makoto, Natalia +	Africa
McAllister, John	Scottish	Malone, Robert James +	Asia Pacific
McCartney, Errol Peter	International	Mandu, Richard Wananda +	Africa
McGrath, Laeona	Southern	Mathews, Mathai Junior	Africa
McGroarty, Graeme	Southern	McFarlane, Angus Black +	Africa
McKay, Mathew John	Asia Pacific	McLoone, Fiona +	Southern
McKeown, Pdraig Thomas	Irish	Mugume, Alex Richard +	Africa
Mitula, Willis Alfayo	Africa	Murray, Jean Alexandra +	Scottish
Mkaruka, Renuat Kaitira Malembo	Africa	Mutanga, Pascal T. C. +	Africa
Mkemangwa, Dominic Galiusa	Africa	Ndung'u, Issac Nderitu +	Africa
Mkhwanazi, Penelope	Africa	Okello, Christopher Oloya	Africa
Morar, Jayshree	Africa	Okello, Tobias +	Africa
Mugume, Alex Richard +	Africa	Price, Andrew C. +	Southern
Nagandi, Saphan	Africa	Purcell, Susan +	Great Northern
Nunda, Omondi Matthews	Africa	Ryan, Siobhan	Irish
Nyaki, Julius Stephen	Africa	Sanchez Avila, Pedro Humberto	International
O'Connell, Norma Mary +	Irish	Scott, Alexander Paul +	Southern
O'Connor, Cam A.	International	Smith, Laura Ann +	Asia Pacific
Ogansuyi, Benjamin Uwadia	Africa	Smith, Simon Andrew +	Midland
O'Hanlon, Ross Patrick	Irish	Subramanya, P.G. +	Asia Pacific
Okello, Tobias +	Africa		

Te Focht, Robertus Hendricus Johannes	International
Terharn, Susanne +	International
Thacker, Martin S +	Great Northern
Tolly-Lolo, Nathalie Rose +	Africa
Van Den Hoogen, Marijke +	International
Wafula, Peter +	Africa
Watts, Emma Louise +	Southern
Worth, Nigel Vincent +	Midland

### Associate Membership Examination (Distilling)

#### - Passes

#### AME module one (distilling)

Drennan, Matthew	Scottish
Watt, Peter Matthew	Scottish
Reaich, Donna +	Scottish

#### AME module two (distilling)

Mercer, Grant	Scottish
Bremner, Joyce Mary Elizabeth	Scottish
Hunter, Stuart Daniel	Scottish
Murray, Phillip Gordon	Scottish
Cairns, William	Scottish

#### AME module 3 (distilling)

Winchester, Alan John +	Scottish
Cairns, William	Scottish
Okech, Patrick	Africa

*++Has passed all modules of the DMB by accumulation*

*+Has passed all modules of the AME by accumulation*

*\*\*Pass with Distinction and J S Ford Award*

*\*Pass with Distinction*

## QUESTION PAPERS AND EXAMINER'S REPORTS

### Associate Membership Examination (brewing) 2001

#### Question papers for module 1 – materials and wort

Monday 4<sup>th</sup> June 1000 – 1300

Answer any SIX questions. All questions carry the same mark of 20.

(The marks allocated to parts of questions are shown in brackets [ ] and you are strongly advised to allocate your time accordingly.)

1) Describe the structure of the barley grain. [10]

Explain the role of gibberellins in modification of the endosperm. [10]

2) Outline the operational stages involved in processing barley into malts. Explain the main aims of each stage and how these aims are achieved. [20]

3) What are the requirements of a good quality malt for brewing? [20]

4) What is the role of calcium ions in wort production? [8]

Describe the techniques available for removal of any two of the following from water used for brewing:

Iron; [6]

Manganese; [6]

Nitrate; [6]

5) Describe basic principles of temperature-programmed mashing and explain its merits compared to a single temperature process with respect to final wort composition. [20]

6) Discuss the range of liquid adjuncts that are used in a brewery to provide fermentable extract. For each adjunct, describe its composition, basis of manufacture, and effect on brewing. [20]

7) Discuss the constituents of hops that are relevant to brewing and give a detailed explanation of why. [15]

What changes in quality can occur during storage of whole hops? [5]

8) Explain the meaning of the terms **repeatability** (r95) and **Reproducibility** (R95). [5]

Describe the basic principles enshrined in Quality Assurance concepts. [15]

#### Examiner's report for module 1 – materials and wort

199 candidates sat the examination compared to 184 candidates in 2000 and 146 candidates in 1999. 66% of candidates achieved at least a pass compared to 65% in 2000. It is therefore disappointing that the percentage pass rate has not improved significantly. Although only 6% of candidates achieved an A-pass, it is pleasing to report that there were some superb papers. It continues to be regrettable that 6% of candidates failed to answer six questions. A few candidates also missed parts of questions.

**Question 1** (*Describe the structure of the barley grain. Explain the role of gibberellins in modification of the endosperm.*)

This question was answered by 98% of candidates, with 76% obtaining a pass mark and 15% an A-grade pass. The majority of candidates did well on this question and produced a diagram illustrating a longitudinal cross section of a barley grain, annotated to indicate the embryo, endosperm, micropyle, husk, testa/pericarp and aleurone. A number of candidates additionally produced a diagram illustrating the cellular structure of the endosperm containing large and small starch grains embedded in a protein matrix. Most of the candidates also gave a written explanation of each feature of the grain and its biological relevance or importance in malting. There appears to be a common confusion as to the nature of the scutellum, frequently drawn and described as a semi-permeable membrane, not attached to the embryo. Some candidates drew a grain both simultaneously 'resting' and germinating, since both embryonic root initials and well-developed rootlets were drawn.

Most candidates correctly indicated that gibberellins are produced in the germinating embryo, and are carried

with imbibed water through to the aleurone where enzymes important for modification are produced de novo and exported to the endosperm. Good answers described which enzymes were produced, and which order, and what the enzymes did in the endosperm (substrate and product), and also the relevance of this to the modification process. The majority of candidates also described how exogenous gibberellic acid can be added during the malting process to augment that produced by the embryo. Some of the poorer answers confused enzymes with hormones.

**Question 2** (*Outline the operational stages involved in processing barley into malts. Explain the main aims of each stage and how these aims are achieved.*)

This question was answered by 98% of candidates, with 89% obtaining a pass mark and 23% an A-grade pass. This was a question that most candidates could get their teeth into since it covers the basics of practical malting. Good answers indicated that barley grain of the correct quality (the testing was also sometimes described) must be cleaned, dried and graded before the processes of steeping, germination and kilning in order to produce well modified malt of the correct enzymatic and flavour specification. The main aims of each process were generally well explained, as were the processes carried out to achieve these. Better answers pointed out potential problems during each stage (for example spoilage during storage, water sensitivity, over-modification, or the production of nitrosamines), and ways in which these problems could be avoided or remedied. Some candidates probably spent too much time illustrating the machinery that is involved rather than explaining the purpose of each particular stage.

**Question 3** (*What are the requirements of a good quality malt for brewing?*)

This question was attempted by 88% of candidates, with 65% achieving a pass mark and 29% achieving an A-grade pass. A good answer to this question should have included details of the expected percent moisture, hot water extract, cold water extract, fine/coarse difference, diastatic power, dextrinizing units, colour, total soluble nitrogen, total nitrogen,  $\alpha$ -amino nitrogen and extract fermentability. Along with the above specifications, candidates should also have included the Kolbach index or soluble nitrogen ratio, along with other important specifications such as friability, homogeneity,  $\beta$ -glucanase,  $\beta$ -glucan, NDMA and SMM as a source of DMS. Good candidates also included the need for a uniform size of corns, the absence of stones, and the absence of a musty odour, along with no evidence of infection or insect infestation. Good candidates emphasised the need for a well modified barley grain with sufficient enzyme activity to produce the necessary fermentable extract. Such candidates also highlighted the type of malt they were describing and what type of beer it would be used to produce. For example, high enzyme levels would be required if certain adjuncts were being used. Good candidates were also able to provide specific values for the above parameters, along with the appropriate units. There were too many answers to this

question where the above parameters were given without any specific values. For example, some candidates said it was necessary to have a “good” diastatic power, or a “good” friability. Such terms as “good” or “poor” need to be backed up by statements as to what precisely are “good” or “poor” values. To obtain a high mark in this question, it was also necessary to explain why the parameters are necessary in a good quality malt for brewing. Weak candidates failed to explain the reasons why the parameters they had stated were important.

**Question 4** (*What is the role of calcium ions in wort production?*)

This question was attempted by 61% of the candidates, with 53% of these candidates achieving a pass and 9% achieving an A-grade pass. The first part of the question concerning the role of calcium in brewing was generally well attempted with most candidates highlighting the effect of pH reduction during mashing and boiling. The differences between candidates were in how many other roles of calcium were identified and also how much explanation was presented to back up the statements. For example answers stating only that calcium reduces pH contrasted with answers giving full explanations and equations for phosphate, phytin and protein interactions, the increase in  $H^+$  concentration and hence the lowering of pH.

The second part of the question on ion removal was generally poorly answered and was the main area where marks were lost. Good answers identified one or more removal techniques and described the technique, as requested in the question. Poor answers either failed to identify any viable techniques or only identified the technique name e.g. “ion exchange” without any description or qualification as to the type of ion exchange unit to be used. Knowledge of iron and manganese removal was slightly better than nitrate, and a number of answers identified activated carbon as a cure for all. Very few answers mentioned costs or relative efficiencies of the techniques.

**Question 5** (*Describe basic principles of temperature-programmed mashing and explain its merits compared to a single temperature process with respect to final wort composition.*)

This question was attempted by 81% of candidates, with 71% of these candidates achieving the pass mark and 24% achieving an A-grade pass. Most candidates provided clear, annotated diagrams of temperature programmed and single temperature regimes, with a few also providing good diagrams for decoction mashing. General omissions were the scales on the time x axes and occasionally also on the temperature y axes. The underlying principles of temperature programmed mashing were generally well understood, although there was a wide range of temperature “optima” quoted for the various enzymes. Almost all answers picked out that temperature programmed mashing can use less well modified malt and a high adjunct level compared with single temperature mashing requiring well modified malt and less adjunct. A few students confused the roles of  $\alpha$  and  $\beta$ -amylase in starch degradation and there was a range of responses on

the role of other enzymes – proteolytic, glucanases, dextrinases and solubilases - from nothing to detailed descriptions of their roles. Single temperature mashing was less well presented or understood with little said about the selection of the temperature, mash thickness and process procedures. The best answers provided clear two-column tables or lists highlighting the differences between the two regimes with regard to materials used, process parameters and the wort composition obtained.

**Question 6** (*Discuss the range of liquid adjuncts that are used in a brewery to provide fermentable extract. For each adjunct, describe its composition, basis of manufacture, and effect on brewing.*)

This question was attempted by 54% of candidates, with a pass rate of 44% of these candidates achieving a pass mark and 14% achieving an A-grade pass. A good answer to this question should have focussed on the production and use of liquid adjuncts from a starch based source and a sucrose based source. Starch sources could have included corn (maize) and wheat, as well as liquid adjunct produced from barley syrup and malt extracts. The answer should have included a description of how sucrose could have been extracted either from sugar cane or sugar beet, with a minimum level of impurities and the removal of colour by anionic exchange. Sucrose can be stored at 20°C. Sucrose is also a source of invert sugar produced by the action of invertase. Invert sugar which consists of 50% (w/v) glucose and 50% (w/v) fructose can be particularly sweet because of its fructose content. The production of liquid adjuncts from a starch based source should have described how starch was extracted from the grain and how the liquified starch could then be treated to provide fermentable sugars. Such treatments could either be based on acid/enzyme hydrolysis or enzyme/enzyme hydrolysis. A variety of different syrups can be produced ranging from those with very high glucose levels to those with very high maltose levels. Where barley and malt extracts provide the starch source, the final syrups contain nitrogen so that amino acids for yeast growth are not diluted to the same extent with such syrups.

There are many affects that liquid adjuncts have on brewing. However, they do provide a very effective way of increasing brewhouse capacity without major capital expenditure. They may also dilute the colour of the wort and reduce the  $\alpha$ -amino nitrogen levels available for fermentation unless they themselves contain nitrogen. The ratio of glucose to maltose in the adjunct can also affect the production of esters.

Many candidates were aware of the major liquid adjuncts that can be used in a brewery. However, their knowledge of production and composition of many of these adjuncts was minimal. Many candidates failed to give any detailed information on different compositions of starch based syrups even although the composition of such syrups is crucial in establishing their fermentability and potential flavour compounds produced by yeast. A surprisingly high proportion of candidates also failed to mention the use of syrups from barley or from malt extracts, both of which contain nitrogen which is available during fermentation. Most candidates were able to

describe how liquid adjuncts can increase brewhouse capacity without large amounts of capital expenditure. However, many candidates failed to identify any effects of liquid adjuncts on available nitrogen for fermentation, or to identify any major effects liquid adjuncts have on flavour. It was apparent that a number of candidates did not read the question carefully because they devoted a large amount of their answer to the use of solid adjuncts. This could have been because the focus of their study had been on the use of solid adjuncts rather than liquid adjuncts. The aim of the syllabus is to ensure that candidates have a broad appreciation of the materials used in wort production and how they are used. Candidates should therefore not attempt to ‘question spot’, but should study the whole syllabus carefully.

**Question 7** (*Discuss the constituents of hops that are relevant to brewing and give a detailed explanation of why.*)

This question was answered by 90% of candidates, with 63% obtaining a pass and 16% obtaining an A-grade pass. This question was generally answered well by candidates. Almost every candidate was able to identify the fact that there are two types of hop resins, hard resins and soft resins. The soft resins contain  $\alpha$ -acids and  $\beta$ -acids, and it is the isomerisation of  $\alpha$ -acids during wort boiling that provides bitterness to the beer. Many candidates identified how the utilization of  $\alpha$ -acids depended on wort pH, gravity of the wort, and vigor of the boil. However, utilization of  $\alpha$ -acid is often significantly less than 40%. Utilization can be significantly increased by the use of isomerised hop extract. A number of candidates described how these are produced. Many candidates also described how the oxidation of  $\beta$ -acids can produce hulupones which can give a harsh bitterness. Many candidates also described how essential oils can contribute to aroma of the final beer. Essential oils are made up of three groups, the hydrocarbons, oxygenated compounds and sulphur compounds. Weaker candidates failed to identify how such essential oils are readily lost during wort boiling and therefore they need to be added within the last 5 to 20 minutes of the boil. Weaker candidates also failed to identify the different types of flavour produced by the above groups of compounds. Hops can also be added to beer after fermentation to give beer a dry hop flavour often described as “resinous” “spicy” or “citrus”. There were too many candidates that failed to describe how tannins from hops can precipitate with protein during wort boiling to produce the hot trub. Tannins can increase the reducing power of beer and can also lead to chill hazes and bitter tastes in the final product.

Most candidates were aware that there was a loss of  $\alpha$ -acid during storage. However, the loss of bittering potential is partially offset by oxidation of  $\beta$ -acids to hulupones with harsh bitterness. Soft resins are converted to hard resins. Many candidates were aware of the development of a ‘cheesy’ aroma in hops during storage, but very few candidates were able to describe how this oxidation was due to the cleavage of the acyl side chain of hop resins releasing isobutyric, isovaleric and 2-methylbutyric acids. Very few candidates mentioned that

hop oils can show an increase of volatile acids over three years from 1-3% to 20%. A number of candidates identified the need for storage at 12% moisture to avoid the dangers of discolouration and microbial infection.

**Question 8** (*Explain the meaning of the terms repeatability (r95) and Reproducibility (R95). Describe the basic principles enshrined in Quality Assurance concepts.*)

This question was undertaken by only 24% of the candidates, with 40% passing and 8% of the answers at A-grade. It was surprising how few candidates were able to define the terms 'repeatability' and 'reproducibility'. Repeatability is an internal laboratory check in which the same sample is analysed by the same analyst, using the same equipment, at the same time. The results should fall within a stated specification range 95% of the time. Reproducibility is a between laboratory check and the results should again fall within the stated specification range 95% of the time. In the case of reproducibility, the same sample is analysed by different analysts, using different equipment, at different times. Very few candidates were aware that the data obtained had to fall within a stated specification. Almost all brewers will be provided with data on their raw materials or data obtained during production. I am aware that many of those working in a brewery may be unaware of the precise methods used within a laboratory. However, it is essential that when provided with data, all brewers have some feel for the precision with which the value they have been given is accurate. Biological material is variable and sampling of biological material will pick up the variability. All candidates should have an understanding of the terms 'repeatability' and 'reproducibility'. Candidates should also familiarize themselves with laboratory methods, even although they may not be carrying out these methods themselves.

The basic principals of quality assurance differ from quality control procedures that focus on making sure that the product is within specification. There have been different frameworks used to ensure that there is management of quality throughout production. These include ISO 9000 frameworks and HACCP. The frameworks set out to establish clear protocols for all employees with given courses of action if any problems are identified. Within any of the frameworks, it is necessary to have specified procedures to follow, and documentation to ensure that these procedures have been followed. A quality assurance system should set down specifications to identify the target for any particular process. It should set out the procedures that explain clearly what has to be done, when it should be done, and how. To ensure that the procedures are followed, it is necessary to have documentation that records what has been done and such documentation must be correct. There is a requirement that the procedures and specifications are monitored on a regular basis and that where problems arise these are highlighted and dealt with. If quality assurance is to achieve its objective, then there must be continual auditing of the system to ensure that procedures are being followed and, where necessary, corrective action

is taken to alter procedures that are leading to problems. Finally, there needs to be continual review to ensure that corrective actions are taken and improvements made where necessary. A number of candidates focussed on analytical techniques and the need to ensure that the analytical equipment was accurately calibrated. This would be an important part of any quality assurance framework. However, a number of candidates went out of their way to describe in detail the specifications that should be achieved in producing a beer. This totally misses the point that the concepts of quality assurance are designed to ensure that a product is correctly produced at all stages of production.

This question was undertaken by only a few candidates and I suspect this is because this is a new part of the syllabus. Quality assurance concepts are becoming integral parts of brewing practice and all candidates should be aware of the concepts.

### Summary

In my last report, I noted that a number of candidates were providing poorer answers to the final questions that they tackled and that there was evidence that this was due to a lack of time. It is pleasing to report that many of the top candidates demonstrated they could divide their time effectively between questions and obtain excellent marks in all of their answers. It is also pleasing to note that in a paper on 'raw materials', many of the candidates gave superb answers on the questions relating to barley and malt production. It is also encouraging that there was an excellent grasp of how hops are utilized in brewing and the key components that are present in hops. It is clear, however, that many candidates knew insufficient about the role of various ions in wort production. Candidates also seemed unaware of how excess ions could be effectively removed from water used for brewing. Another feature of the answers was the lack of knowledge about quality assurance concepts. This is an area that has developed rapidly and has been newly incorporated into the syllabus. Candidates should in future ensure that they are familiar with concepts relating to quality assurance. The part of that question relating to laboratory techniques was also poorly answered. It is very important that all candidates are aware of the precision with which particular measurements can be made. Analysts provide data which enables maltsters and brewers to decide whether the raw materials or product they are producing is within specification. While data may be given to you as a single number, it might be that the method provides very variable values on the same sample. If this is so, it is essential that you are aware of it so that you can make the appropriate interpretation of the data given. All candidates should have knowledge of the laboratory methods used to provide a specification for either their raw materials or their products.

There is evidence from a number of papers that candidates were trying to pass on knowledge based on the particular part of the production process with which they were very familiar. In preparing for the AME, candidates should take care to ensure that they cover the whole syllabus. Wherever possible, candidates should ensure

that they are reading the Journal of the Institute of Brewing and the Brewer International on a regular basis, both published by the Institute and Guild of Brewing. The articles in these publications will broaden your knowledge, knowledge that will greatly enhance the effectiveness with which you are able to work in a maltings, brewery, or related laboratory or production process.

### **Question papers for module 2 – yeast and beer**

Monday 4<sup>th</sup> June 1400 – 1700

Answer any SIX questions. All questions carry the same mark of 20.

(The marks allocated to parts of questions are shown in brackets [ ] and you are strongly advised to allocate your time accordingly.)

- 1) Write detailed notes on:
  - a) the principles of preserving pure cultures of brewing yeasts in the laboratory, [10] and
  - b) the practical features involved in propagating pure yeast for brewery fermentations. [10]
- 2) Describe the origins, measurement and control of beer colour. [20]
- 3) Outline the available methods for the detection of and quantification of beer spoilage aerobic and anaerobic bacteria and wild yeasts in filtered beer and in packaged beer. [20]
- 4) Write an essay on the conditioning/ maturation of beer. [20]
- 5) Discuss, in detail, how the levels in wort of:  
assimilable amino nitrogen,  
molecular oxygen,  
and zinc ions  
will influence the progress of a brewery fermentation. [20]
- 6) Describe the factors that can affect flavour stability during prolonged storage of packaged beer. [20]
- 7) Write detailed notes on **TWO** of the following topics:
  - a) flocculation of yeast [10]
  - b) how hop bittering substances can influence beer quality [10]
  - c) the methods of predicting and measuring non-biological haze [10]
- 8) Describe the features required for satisfactory cleaning systems for brewery fermentation vessels. [8]  
Outline:
  - a) the range of appropriate cleaning and sterilising materials, [6] and
  - b) the procedures available to monitor for residual surface contamination. [6]

### **Examiner's report for module 2 – yeast and beer**

One hundred and seventy two papers were entered (five of which were for the Distilling option), with an overall pass rate of 86%.

This pass rate is a significant increase over that achieved in recent years (cf 74% last year, 73% in 1999). This is a particularly pleasing result, since over 9% of candidates were awarded grade A, with a further 20% achieving grade B. Especially encouraging was the upward trend in the overall quality of presentation.

Unfortunately, some candidates clearly attempted to answer some questions without heeding the precise wording, with a tendency to stray from the major point of the appropriate answer.

Question 7 proved to be the most popular, with over 88% of candidates selecting it, although questions 4 and 8 had the best pass rates (at over 86% and 87%); question 3 was by far the least popular question.

**Question 1** (*Write detailed notes on a) the principles of preserving pure cultures of brewing yeasts in the laboratory, and b) the practical features involved in propagating pure yeast for brewery fermentations.*)

77% of candidates attempted this question, with 81% gaining pass marks or above.

Most answers described satisfactorily the key principles of preservation of stock yeast cultures, noting that several different procedures are available and listed the advantages and disadvantages of the various procedures. Good answers identified that the requisite features of any method of preservation are to ensure that no changes in the yeast's character occur and that a high survival rate is achieved.

Low temperature storage (at -70°C refrigeration or under liquid nitrogen) usually achieves optimum results, provided that the rather costly equipment is available, since cultures at a low temperature have the lowest death rate and are readily revitalised, with little or no adverse effect on other key characteristics; contract low temperature storage is also available. However, storage at 4°C on nutrient agar achieves good preservation, is relatively inexpensive, but with the downside that routine and regular sub-culturing (at least 6 monthly) is essential. Lyophilization (freeze-drying) has been used satisfactorily by some brewers, but it is not generally recognised as the optimum procedure for brewing yeast preservation.

The second part of the question required an outline of the practical features of yeast propagation and many answers provided a clear description of a typical propagation schedule or (in many cases) a detailed description of the actual scheme in use in the candidate's own brewery. Many candidates included a useful diagram of an idealised propagation vessel. The best answers stressed that although the main objective is to achieve maximum yield of yeast mass, it is also important to use growing conditions (wort gravity, temperature) very similar to actual beer production fermentation conditions, especially in the later propagation stage(s), prior to transfer to commercial brew size. The importance of aeration and availability of zinc should also be considered, with major emphasis noted on sterility and

overall hygienic design of propagation plant and environment.

**Question 2** (Describe the origins, measurement and control of beer colour.)

This question was quite popular, with some 77% of candidates tackling it and over 80% achieving the pass mark.

Most answers provided clear descriptions of the origins of beer colour, being predominantly from melanoidins formed during malt kilning and wort boiling. Many candidates provided very detailed accounts of melanoidin formation, arising from Maillard reactions and Amadori re-arrangements, involving the condensation of amino acids and reducing sugars, followed by polymerisations, and also indicated that oxidation of malt and hop polyphenols can also contribute to beer colour. It was frequently commented that, in pale beers (that is beers not produced from extracts containing a significant proportion of coloured malts), about one third of beer colour is produced during malt kilning, with the other two thirds produced during wort boiling. From this estimation, it is quite straight forward to define the appropriate methods for controlling beer colour, viz. defining malt specifications and grist recipes relevant to the target beer specification, ensuring materials conform to the appropriate colour standard, but also ensuring consistency of process conditions during boiling (such as temperature, heating time, stand time, etc), but also controlling oxygen ingress throughout wort production (including milling). Comments on use of caramel and other colourants would also be relevant.

Several answers only glossed over the principles of colour measurement and appropriate methods. However, top quality answers included precise descriptions of comparator and spectrophotometric methods, indicating their inadequacies regarding assessment of hue and described, in detail, the principles and benefits of the more modern approaches of “3-dimensional” colour measurement or chromaticity.

**Question 3** (Outline the available methods for the detection of and quantification of beer spoilage aerobic and anaerobic bacteria and wild yeasts in filtered beer and in packaged beer.)

This question proved to be particularly unpopular in that only 36% of the candidates replied to this question, but with a relatively high degree of success (79% gained a pass grade). However, several answers did not fully reflect the exact question, which clearly required details relevant to FILTERED and to PACKAGED BEER.

Only a few candidates identified that, in the main, packaged beer will have been pasteurised or sterile filtered and that the appropriate procedures will be designed to assess relatively large volumes (possibly even whole package contents) by membrane filtration. Similarly, it is to be expected that only low levels of organisms should be present in beer post-filtration. Good answers also set out by defining beer spoilage (as generating off-flavours, causing physical defects such as haze or even “rope”, possibly leading to product safety concerns and even tax/excise issues).

Outline description of detection procedures was required, bearing in mind that general growth media would probably suffice for packaged beer, where the main requirement will most commonly be to cross-check that sterilisation has been effective. There are merits in identifying the types of contaminating organisms surviving in filtered beer, using classical microbiological methods of growth on specific media, Gram staining, catalase and oxidase testing and assessing colony morphology. However, several candidates chose to present very detailed accounts of all microbiological methods (virtually reciting entire laboratory manuals!), which was not necessarily in keeping with the requested “outline”, although being able to indicate knowledge of the risks associated with wild yeasts, plus lactic acid and acetic acid bacteria and more unusual organisms (such as *Zymomonas* and *Megasphaera*) was valued.

Many candidates glossed over quantification procedures, but several described plate counting after membrane filtration as most appropriate and to set appropriate standards or targets. Several candidates failed to identify the value of Forcing tests in these particular applications, however. First class answers also included brief descriptions and assessments of modern, rapid detection methods (such as ATPase methods, API systems, ELISA assays, etc).

**Question 4** (Write an essay on the conditioning/maturation of beer.)

This question was one of the best answered of the whole paper and appeared to be very popular, with 82% selecting it and over 86% achieving the pass mark. Interestingly, some answers were of a very high standard, indicating that this topic was very well understood by most candidates. One criticism that could be made was that few candidates presented their answer in true essay format.

Ideally, answers should have indicated that maturation of beer is, in reality, a continuation of primary fermentation, although it is often carried out in a separate plant.

“Maturation”, “conditioning” or “lagering” involves processes that achieve:

- flavour maturation: improvement in “green” beer flavour by warm and cold maturation; warm – to reduce diacetyl by yeast absorption, followed by cold – at 0°C or less, to allow continued reduction of unpleasant flavours (acetaldehyde, sulphur compounds), but without involving yeast activity;
- conditioning: a low level of additional fermentation can occur to increase carbon dioxide levels, especially if CO<sub>2</sub> top pressure is maintained over the maturing beer; this secondary fermentation may also involve addition of “priming” sugar (especially in ales) to provide more fermentable material, or by classical “krausening” (in lagers), by addition of fresh wort and yeast; significant flavour modification can occur as a result of secondary fermentation;
- clarification: yeast and insoluble protein particles will sediment out at this stage; clarifying agents, such as auxiliary and isinglass finings, can assist with this

sedimentation, or the whole process can be accelerated by centrifugation;

- stabilisation: to ensure that beer is stabilised against subsequent haze formation, maturation includes cold storage at 0°C or less to allow for insoluble protein/polyphenol complexes to develop (to be subsequently removed by filtration); stabilisation can be enhanced by: addition of absorbents such as silica hydrogels and xerogels (to absorb protein) or PVPP (to absorb polyphenols); addition of precipitants such as tannic acid (to precipitate protein); addition of proteolytic enzymes such as papain (to hydrolyse protein to smaller, more soluble peptides); these stabilising agents, either separately or in various combinations, can actually reduce the time required for cold storage;
- additions: maturation is the most appropriate process stage to make additions and adjustments to “fine tune” to specification, as required or permitted; e.g. colour adjustment with caramel or malt extracts, isomerised hop extracts to increase bitterness, priming sugar, head stabilising agents, etc.

The examiner was also looking for some comments indicating how different maturation methods are appropriate to different beers:

- draught ales are matured directly in final containers (as cask-conditioned beers), where flavour is “finished”, CO<sub>2</sub> level increased and yeast finally settles out (aided by finings),
- lagers are matured in tanks, diacetyl is removed, CO<sub>2</sub> is increased (perhaps requiring krausening), yeast is sedimented, beer is stabilised to ensure “bright” quality is achieved,
- beers for bottling and canning may require additional or more intensive stabilisation to guarantee longer shelf lives.

In all cases, the overriding importance of maintenance of very low levels of dissolved oxygen in beer at this stage can not be over stressed. Finally, mention of modern systems for accelerated maturation would have produced first class answers.

**Question 5** (*Discuss, in detail, how the levels in wort of assimilable amino nitrogen, molecular oxygen, and zinc ions will influence the progress of a brewery fermentation.*)

84% of candidates answered this question, but with a success rate of only 68%. Unfortunately, several candidates elected to present answers that only tackled one or two of the parameters included in the question, failing to recognise the importance of all three as key controlling features of brewery fermentations and this was the main reason for the lower pass rate.

With regard to Assimilable Amino Nitrogen (also known, and usually measured, as free amino nitrogen or FAN and includes predominantly amino acids, small peptides and longer polypeptides), it was most surprising that many candidates failed to appreciate that the major requirement for the amino nitrogen from these compounds is protein synthesis and, hence, yeast growth. Consequently, the progress of any fermentation is very dependent on sufficient FAN being available for optimum

yeast growth. Fortunately, several answers clearly indicated good knowledge of amino acid uptake by yeast; four groups of amino acids are usually recognised on the basis of assimilation patterns, with group A being utilised virtually immediately after yeast pitching, with group B more slowly. Suffice to say here, knowledge of the assimilation of amino acids by yeast, via transamination reactions initially and the feedback mechanisms to synthesise only the necessary amount of appropriate keto- (or oxo-) acids was required. (NB. For future reference, “Blue Book” Brewer’s Yeast, series III, contains all relevant details on assimilation of amino acids during fermentation).

Further discussion on the subsequent production of higher alcohols and, hence, esters as fermentation progresses, plus the influence of amino acid spectrum of wort on beer flavour was also valued. In essence, as nitrogen shortage develops later during fermentation, larger quantities of keto- acids are produced in attempt to maintain synthesis of necessary amino acids. Yeast is not tolerant of high levels of organic acids, which are, thus, reduced to corresponding alcohols and excreted or esterified to produce flavour active esters. In addition, carbonyl by-products (e.g. diacetyl) start to accumulate later in the fermentation profile. Good answers to this section, thus, gave detailed accounts of the far-reaching influences that the amino nitrogen composition of wort has on fermentation performance and on beer flavour.

Molecular oxygen has profound influence on yeast activity, especially on yeast growth. It is somewhat ironic that when yeast is first pitched into wort, some oxygen is essential to stimulate sufficient yeast synthesis for a brewery fermentation (which must subsequently proceed totally anaerobically for alcohol production) to proceed efficiently, but this is the only point in the brewing process where oxygen is beneficial; indeed, it is critically important to exclude oxygen subsequently due to its negative effect on beer quality and flavour stability.

Consequently, candidates should have been able to explain this key role for oxygen at the start of fermentation, in that there is an absolute requirement for molecular oxygen for the biosynthesis of sterols (predominantly ergosterol) and unsaturated fatty acids. Both these lipid classes are significant yeast growth factors, being critical for membrane function and integrity. Good answers emphasised that sterols contribute to the structure and dynamic state of membranes, modulating membrane fluidity under fluctuating conditions, e.g. ergosterol confers resistance to ethanol, so that a decrease in ergosterol levels can lead to reduced cell viability in presence of ethanol, possibly resulting in incomplete fermentations.

In addition, candidates should have described the varying range of oxygen requirements between different yeast strains and of the necessity to increase oxygen levels for high gravity brewing. Finally, top answers explained the relationship between ester formation and wort oxygen content, whereby ester synthesis is reduced by increased oxygen levels due to the promotion of greater yeast growth.

The importance of zinc ions relates to the essential need for trace levels to promote adequate yeast growth,

which can not be substituted by other metal ions. The metabolic role for zinc relates to its essential requirement as a co-factor for the function of many enzymes, especially alcohol dehydrogenase. Clearly, this enzyme is the key terminal step in yeast alcoholic fermentation, so that zinc deficiency can lead to “sticking” fermentations.

The examiner was looking for good answers, not only to address most of the above points, but also to attempt to link together how all three parameters of FAN, molecular oxygen and zinc ions are intimately interrelated to ensure controlled yeast activity and flavour production.

**Question 6** (*Describe the factors that can affect flavour stability during prolonged storage of packaged beer.*)

This question was selected by 68% of candidates, of which 74% achieved the pass standard. In the main, this question was answered well, with most candidates starting out (quite correctly) by defining the packaged beer formats that they were proposing to include. Several answers, in addition to small packs, also included considerations not only of keg beer, but also specific features related to cask- and bottle-conditioned beers.

The key features included clearly related to the progress of oxidation characteristics, with detailed descriptions of the development of off-flavours associated with carbonyl compounds, such as trans-2-nonenal.

Many candidates provided detailed descriptions of flavour changes associated with staling reactions, such as ribes, cardboard, papery, etc. In addition answers stressed the importance of limiting dissolved oxygen/air pickup, not only during packaging, but also throughout processing, even back to wort production.

Many answers also considered the risk of light-striking reactions for beers packaged in flint or green bottles, with detailed descriptions of the light-induced chemical reactions involved in the formation of 3-methyl-2-butene-1-thiol from iso-alpha acids and the use of reduced hop compounds to eliminate this reaction occurring on storage in these susceptible package formats.

Few answers, however, considered the impact of the composition of the actual packaging materials on flavour stability. Several features could have been included here, such as risk of iron or aluminium pickup in cans with insufficient / inadequate can lining, possible concerns from inadequately “cured” lacquer linings, risk of contamination with oleic and linoleic acid residues from bottle “cold end” treatments or similar materials from crown liners. However, some answers included comments on the use of oxygen absorbing or scavenging bottle crown liners.

One feature that concerned the examiner was that too many candidates chose to present detailed descriptions of HAZE instability, whereas the question was clearly directed at FLAVOUR considerations only.

**Question 7** (*Write detailed notes on TWO of the following topics, a) flocculation of yeast, b) how hop bittering substances can influence beer quality, c) the methods of predicting and measuring non-biological haze.*)

88% of candidates answered this two-out-of-three part question, with a pass rate of 76%. This was the most popular question and appears to have been the question with which many chose to finish and, consequently (probably due to time constraints) several answers skimmed over all the requisite details.

On the other hand, however, there were several attempts to answer all 3 sections, further emphasising the need to read ALL questions carefully!

a) Regarding flocculation of yeast, most candidates electing to answer this topic, produced very good summaries of the principal features. However, several answers clearly did not identify precisely the definition of flocculation of yeast as the phenomenon whereby yeast cells adhere in clumps and, EITHER, sediment from the medium in which they are suspended, OR rise to the medium’s surface. It excludes chain formation (i.e. non-segregation of daughter and mother yeast cells during growth).

Good answers indicated that flocculation usually occurs in the absence of cell division and involves specific yeast cell surface components (protein and carbohydrate) interacting with calcium ions and that separation can occur by sedimentation (“bottom-cropping” yeast strains) or by flotation (due to cell aggregates entrapping CO<sub>2</sub> bubbles) for “top-cropping” (usually ale) yeast strains.

In addition, detailed descriptions of the “Lectin” theory of flocculation, involving surface protein and mannan receptors were valued. Knowledge of current theories of genetic aspects, plus comparative assessments of methods usually employed to measure yeast flocculation also achieved top marks.

b) The influence of hop bittering substances on beer quality should have included descriptions of the differing effects on perceived bitterness of the various isomers of iso-alpha acids, including assessments of the relative bittering potentials of di-, tetra-, and hexa- hydro derivatives. In addition, the examiner was expecting comments on:

- the potential influence on the development of light-struck flavour (through the formation of 3-methyl- 2-butene-1-thiol) and the resistance to this afforded by reduced hop compounds,
- the antiseptic properties of iso-alpha acids towards gram-positive bacteria (like lactic acid bacteria),
- the foam positive attributes of alpha- and iso-alpha acids, with the reduced products (especially tetra- and hexa- hydro compounds) being particularly foam active,
- oxidation products of alpha- and iso-alpha acids being implicated as potential causative agents of gushing (or uncontrolled over foaming of beer).

c) The methods of predicting and measuring non-biological haze was the most poorly answered section of this question, probably because, as indicated above, many answers were very skimpy (because of time constraints?). In addition, many candidates insisted on describing microbiological haze concerns (either in addition to or instead of the required non-biological hazes).

Further, although it is understood that specifying precisely the ideal analysis for malt and other extract

materials (and analysing delivery samples accordingly) for parameters such as polyphenol and protein/ total nitrogen contents can be of value in ensuring good control of haze stability, the examiner was expecting that more complete answers would include detailed, comparative assessments of the effectiveness of various published laboratory procedures for measuring haze and predicting potential haze concerns during drinking life (related to the potential formation of polyphenol/protein/hop compound/metal ion complexes).

Such methods include nephelometric measurement techniques (either forward or backward scatter or at 90° to incident light) with various accelerated tests involving heating and cooling of beer (over various cycles), plus forcing tests using alcohol addition and extended very low temperature cooling (e.g. Chapon test), plus precipitation tests for “sensitive” protein (e.g. by addition of saturated ammonium sulphate or tannic acid) or polyphenol content (e.g. by direct analysis or by removal with PVPP). Automated analytical procedures, using instruments such as Tannometer (incorporating several different tests in parallel) could also have been described.

**Question 8** (*Describe the features required for satisfactory cleaning systems for brewery fermentation vessels. Outline: a) the range of appropriate cleaning and sterilising materials, and b) the procedures available to monitor for residual surface contamination.*)

This was the best answered question in that over 87% of candidates achieved the pass mark, although only 75% attempted it; there were, again, some exceptionally good responses. Although most candidates answered all the sections of the question thoroughly, there was a tendency to over-emphasise the first part of their answers at the expense of providing sufficient detail in the latter two sections.

The best answers stated the required level of cleaning appropriate for fermentation vessels as necessarily microbiologically clean; that is, cleaned to a degree such that no physical or microbiological contamination remains. Further, the type of “soil” to be removed needed to be identified, which would include: yeast, protein, tannin, sugar, oxidation products and scale. From this basis, it is straight forward to design the appropriate cleaning system, which, for closed vessels, should include CIP with detergent and disinfectant/ sanitiser. Several answers failed to recognise that open fermenters still exist and that the appropriate cleaning system in this case, may be manual, followed by rinsing with disinfectant.

Many answers included very detailed descriptions of recovery CIP systems, with elaborate diagrams. No answers were penalised for this detail, but the better answers also described the basis on which these systems have been designed and clearly identified the ideal cleaning cycle features. These involve firstly CO<sub>2</sub> removal, prior to pre-rinsing to remove gross loose soil, followed by detergent recirculation to clean vessels, pipework and sample points, followed by rinsing with clean water, perhaps with added disinfectant; the use of pulsed rinse cycling may be appropriate, especially to avoid “puddling” and rating the scavenging system greater than the supply system is also clearly advantageous in this respect.

Good answers also outlined the process of detergency, including the following stages:

- surface wetting, to allow intimate contact between detergent and soil,
- correct chemical action on the soil, viz. acid on mineral scale, hydrolysis to solubilise protein, saponification by caustic of “fatty” deposits,
- dispersion of large to finely divided particles,
- suspension in solution of soil for easy removal.

The section on appropriate materials for cleaning and sterilising was well answered, with, in many cases, more than the requested outline information being presented. This really amounted to brief descriptions of detergent formulations (e.g. caustic base, with added sequestrants and surfactants), while some discussion on the most appropriate sterilants was also required (such as peracetic acid, biguanides) identifying any risks associated with residues.

The last section was also well answered, with many candidates clearly aware of the relative merits (and short comings) of swabbing, assessment of rinse liquors, use of ATPase systems, etc., but not forgetting the value of visual assessment (either by viewing directly or by assessing the “wettability” of the clean surface with clean water).

### **Question papers for module 3 – packaging and process technology**

Tuesday 5<sup>th</sup> June 1000 – 1300

Answer any SIX questions. All questions carry the same mark of 20.

(The marks allocated to parts of questions are shown in brackets [ ] and you are strongly advised to allocate your time accordingly.)

1) A beer, which has been filter-sterilised, is to be packaged so that the end product is still microbiologically stable. Explain fully the basic principles of the additional precautions (excluding pasteurisation) that are required to ensure the microbiological stability of the packaged product. [20]

2) Describe the differences between laminar and turbulent flow including sketches of velocity profiles in pipes. Discuss the relevance of the two flow regimes in brewing and explain the significance of the Reynolds number in describing fluid flow. [8]

Cold wort with a density of 1080 kg m<sup>-3</sup> and viscosity 0.003 kg m<sup>-1</sup> s<sup>-1</sup> flows down a 50 mm diameter circular pipe at a rate of 3.5 kg s<sup>-1</sup>. Find the mean velocity ( $u$ ) of the wort in the pipe and determine the centre-line velocity ( $u_{CL}$ ) given that:

$$u = 0.5 u_{CL} \text{ for laminar flow}$$

$$u = 0.82 u_{CL} \text{ for turbulent flow. [6]}$$

The wort is delivered to a tank through an outlet nozzle of 15 mm diameter (point B), which is situated 3 m above the 50 mm diameter section of pipe (point A). If the pressure at point A is 150 kN m<sup>-2</sup> calculate, neglecting frictional effects, the pressure at the outlet. [6]

3) Describe the basic principles of in-place cleaning (CIP) in a packaging plant. [10]

How would you ensure microbiological integrity and chemical cleanliness of a specified returnable package? [10]

4) Hot condensate is collected from four points in a brewery and combined before being used in a pre-heat exchanger. What will be the temperature and flow rate of the combined stream if the flow rates and temperatures of the individual streams are as follows? [6]

- 3 kg s<sup>-1</sup> at 70°C
- 0.75 kg s<sup>-1</sup> at 92°C
- 1.5 kg s<sup>-1</sup> at 85°C
- 1.25 kg s<sup>-1</sup> at 68°C

It is proposed to use the combined stream in a counter-current heat exchanger to pre-heat a liquor from an initial temperature of 20°C to within 5°C of the combined condensate stream temperature. Calculate the heating area required. [14]

**Data:**

- Specific heat capacity of all the condensate streams = 4.2 kJ kg<sup>-1</sup> K<sup>-1</sup>
- Overall heat transfer coefficient of the heat exchanger = 1200 W m<sup>-2</sup> K<sup>-1</sup>
- Flow rate of liquor to be heated = 8 kg s<sup>-1</sup>
- Specific heat capacity of liquor to be heated = 3.6 kJ kg<sup>-1</sup> K<sup>-1</sup>

5) Describe three techniques for dissolving gases in beer and discuss their relative merits. [12]

How does supersaturation occur in beer and what are its effects and threats to beer quality? [8]

6) Define the terms “stainless steel” and “Austenitic stainless steel”. [4]

Name three commonly used Austenitic stainless steel alloys and distinguish them in terms of their composition and relative cost. [8]

Describe the relevant features of stainless steels suitable for use in brewing. [8]

7) Describe what is meant by the term pasteurisation and illustrate graphically the relationship between time, temperature and lethal rate. [6]

Define the pasteurisation unit (PU) and discuss the effects of pasteurisation on different organisms [6]

Beer containing 1.8 volumes of carbon dioxide (CO<sub>2</sub>) per volume of beer at standard temperature and pressure (STP) is pasteurised at 73°C. Assuming beer has the same molecular weight and density as water, calculate the mole fraction of CO<sub>2</sub> in the beer and the pressure required to maintain it in solution at the pasteurisation temperature. [8]

**Data:**

- Density of water is 1000 kg m<sup>-3</sup>
- Molecular weight of carbon dioxide is 44.
- Molecular weight of water is 18.
- Henry's constant for carbon dioxide in beer at 73°C is 440 MPa mole fraction<sup>-1</sup>.
- Note: STP is 0°C, 0.1013 MPa.

8) By reference to a **suitably labelled diagram**, explain the means by which the temperature of a cylindrical

fermenter may be controlled during the course of fermentation. In giving your answer, make particular reference to: [10]

a) the control loop involved, the type of sensor used to measure the temperature of the fermenter contents.

A cylindrical fermenter containing 500 hl of beer is cooled from 15°C to 12°C in 1 hour 45 minutes by coolant flowing at 3.2 kg s<sup>-1</sup> which enters the cooling jacket at minus 5°C. Calculate the average rate of heat removal from the beer (J s<sup>-1</sup>) and the outlet temperature of the coolant. [10]

**Data:**

- Density of the beer is 1008 kg m<sup>-3</sup>
- Specific heat of the beer is 4.15 kJ kg<sup>-1</sup> K<sup>-1</sup>.
- Specific heat of the coolant 3.5 kJ kg<sup>-1</sup> K<sup>-1</sup>

9) Choosing a particular form of **primary** packaging, describe its basic properties. Discuss the marketing and legal implications and environmental effects of your chosen packaging. [15]

What impact might the choice of packaging type have on the properties of the beer? [5]

### **Examiner's report for module 3 – packaging and process technology**

A total of 139 candidates sat this examination with 105 achieving a pass, giving a slightly higher pass rate (75%) than last year (71%). This is again an extremely good all round performance, demonstrating the level of preparedness of most candidates. Following changes to the syllabus during the past year (to include more on packaging) an additional question was added to this year's paper, to give greater choice to candidates (answer six from nine questions rather than the usual six from eight). This did not appear to have any major effect on the candidates though it did, of course, mean more work for the examiner! The overall distribution of marks was good, with ten (7%) achieving A grades, (slightly down on last year) 24% achieving grade B, 26% C, 19% D, 16% E, 6% F and just 2% getting grade G. The same comment as last year can be made – particularly to those who failed – that some diagrams and text were virtually illegible and there is barely any point drawing a very poor diagram, which nobody but the drawer can interpret. Clear, well-labelled diagrams, on the other hand, can assist an answer greatly. Numerical sections were generally answered well, being laid out in a logical manner with steps in the calculation shown clearly and often with checks on units included.

**Question 1** (*A beer, which has been filter-sterilised, is to be packaged so that the end product is still microbiologically stable. Explain fully the basic principles of the additional precautions (excluding pasteurisation) that are required to ensure the microbiological stability of the packaged product.*)

One of three questions relating directly to the newly increased emphasis on packaging in the updated syllabus, this question was attempted by only 51% of the candidates. This made it the second least popular question after question 9 (47%), which was also concerned with packaging. These two questions also produced the lowest average marks (both 50.8%) and lower than normal pass

rates (62% and 68% respectively). The lack of textbook coverage of packaging aspects and the newness of such aspects in the syllabus almost certainly contributed to this relatively poor performance. Despite this there were some very good answers, with two candidates achieving full marks.

Good answers included explanation of essential general principles such as: ensuring that anything coming into contact with the package is free of microbial contamination (e.g. by sterilisation of pipe-lines, equipment, rinse water, gases, closures, etc.); maintaining high levels of hygiene and restricted access amongst personnel; carrying out regular microbiological checks. Details of extra precautions taken during plant cleaning, empty package preparation, closure preparation and filling were also necessary for a complete answer. Such precautions as avoiding condensation, using lubricants that cannot support microbial growth, treating with UV or other sterilising radiation, operating the filler room under positive pressure, regular replacement of filler head seals and monitoring CIP agents for potency, were amongst the many offered by candidates scoring highly.

**Question 2** (*Describe the differences between laminar and turbulent flow including sketches of velocity profiles in pipes. Discuss the relevance of the two flow regimes in brewing and explain the significance of the Reynolds number in describing fluid flow.*)

A simple question in three parts, the first of which required a knowledge of velocity profiles and Reynolds number. The second part involved a calculation of centre-line velocity while the final part required calculation of delivery pressure for the same pipe flow problem. This was a straightforward application of continuity and Bernoulli's equation and the majority of candidates tackled it well. Unfortunately, due to an error on the paper (the nozzle diameter should have been 30 mm rather than the 15 mm given) correct calculation gave an impossible answer, though this did not prevent the method from being used. Some candidates recognised the impracticality of the situation while others rationalised it in a number of ways – full credit was given for application of the correct method, regardless of the interpretation given to the answer obtained. Interestingly only one or two candidates commented on the impracticality of the answer and, fortunately, no one appeared to have lost time worrying about it. A total of 78% of all candidates attempted this question with 70% of these achieving the pass mark or higher.

**Question 3** (*Describe the basic principles of in-place cleaning (CIP) in a packaging plant. How would you ensure microbiological integrity and chemical cleanliness of a specified returnable package?*)

Another of the packaging based questions, this was attempted by 60% of candidates and was generally tackled very well with 81% passing. Good answers to the first part identified points particular to CIP in the packaging plant rather than just the basic principles of CIP. The fact that the packaging plant CIP system would be a separate system; that it is an integral part of the packaging process (for package preparation); that it would

differ for sterile-filling and post-packaging pasteurisation; and that different programmes would be required for bright beer tanks, fillers etc., were amongst the specific points given credit. Basic principles of operation can generally be summarised in terms of mechanical action, chemical action, temperature changes and time, with attention also being paid to monitoring and control to ensure effectiveness.

The second part of the question asked how microbiological integrity and chemical cleanliness could be ensured for a chosen returnable package. Some candidates misinterpreted this to mean how can microbiological integrity and chemical cleanliness be demonstrated or proven rather than describing what needs to be done to make sure they are achieved. However, the majority had no difficulty with the question and on the whole it was answered better than the first part. Most candidates chose to describe bottle-washing and used good, clear diagrams to support their explanation.

**Question 4** (*Hot condensate is collected from four points in a brewery and combined before being used in a pre-heat exchanger. What will be the temperature and flow rate of the combined stream if the flow rates and temperatures of the individual streams are as follows? 3 kg s<sup>-1</sup> at 70 °C, 0.75 kg s<sup>-1</sup> at 92 °C, 1.5 kg s<sup>-1</sup> at 85 °C, 1.25 kg s<sup>-1</sup> at 68 °C. It is proposed to use the combined stream in a counter-current heat exchanger to pre-heat a liquor from an initial temperature of 20 °C to within 5 °C of the combined condensate stream temperature. Calculate the heating area required.*)

Just 54% of candidates tackled this question, of whom 77% reached the pass mark. The first part of the question required a simple sum, adding together the input streams to give a total flow rate of 6.5 kg s<sup>-1</sup> and averaging the temperature of the streams (in proportion to the size of each stream) to give a combined temperature of 75.6 °C. Using the information obtained, the second part could be calculated. The cold liquor would be heated to 70.6 °C, which would require  $8 \times 3.6 \times (70.6 - 20) = 1,458$  kW of heat. This would lead to an outlet temperature of 22.2 °C for the condensate stream. Then, using  $Q=UA(LMTD)$  the area required could be calculated to approximately 355 m<sup>2</sup>. Answers based on arithmetic mean rather than log mean temperature difference were also accepted (though with slightly lower marks being awarded). Although not asked for, one or two candidates commented that the area required was rather high. Normally a somewhat higher overall heat transfer coefficient than 1200 Wm<sup>-2</sup>K<sup>-1</sup> might be expected, which would reduce the area required. Seven candidates scored full marks on this question.

**Question 5** (*Describe three techniques for dissolving gases in beer and discuss their relative merits.*)

The second most popular question and most well done, was passed by 82% of the 83% attempting it. The three methods of dissolving gases into beer offered by most of the candidates were, in order of increasing cost but also increasing effectiveness, simple use of top pressure, batch sparging and in-line injection (through a venturi). Explanations referring to a general rate equation, identifying interfacial area, mass transfer coefficient and

concentration driving force as the key parameters made comparisons relatively easy. The second part of the question required a definition of supersaturation in terms of the dissolved concentration being higher than the equilibrium concentration at a particular temperature and pressure. Hence with a sudden increase in temperature or decrease in pressure, gas would break out. Such break-out of gas, encouraged by the presence of dirt particles, seed bubbles or crevices, could lead to foaming or gushing with possible consequences such as increased haze levels, oxygen pick-up and spoilage.

**Question 6** (*Define the terms “stainless steel” and “Austenitic stainless steel”. Name three commonly used Austenitic stainless steel alloys and distinguish them in terms of their composition and relative cost. Describe the relevant features of stainless steels suitable for use in brewing.*)

Of the 60% who attempted this question, 77% passed. The first part required simple definitions, which for the four marks on offer was not worth the lengthy essays some candidates provided. The key feature of stainless steel is the 10% or more of chromium and the “passivation” that this enables, rendering the steel very corrosion resistant. Austenitic stainless steels have an additional feature in that they also contain significant levels of nickel and are even more corrosion resistant. Examples of three commonly used Austenitic stainless steels (in order of increasing cost) are 304, 321 and 316, amongst others. Most candidates were able to compare these in terms of composition and price and were able to describe relevant features for brewery applications, such as corrosion resistance, strength, expansion coefficient (high), heat transfer coefficient (much lower than copper), weldability.

**Question 7** (*Pasteurisation....*)

Almost everyone (93%) attempted this question, with a pass rate of 71%. Most defined pasteurisation as a mild heat treatment used to kill microorganisms and improve the stability of beer (without reducing quality), though many were less able to produce a meaningful graph to illustrate the effects of time and temperature on lethal rate. These are shown very clearly in most brewing text books and in the EBC good practice guide to pasteurisation. The second part of the question was generally answered well with the vast majority of candidates knowing that the pasteurisation unit is the killing effect of holding beer at 60°C for 1 minute. The last part of the question was a straightforward application of Henry’s law and presented no problem for most candidates, who successfully calculated the pressure required as 6.36 bar.

**Question 8** (*By reference to a suitably labelled diagram, explain the means by which the temperature of a cylindroconical fermenter may be controlled during the course of fermentation....*)

Although this was the only question on which no one scored full marks, 73% of the 65% attempting it did reach the pass mark. Good answers included a clear diagram, suitably labelled (as asked for) of a cylindroconical fermenter, showing attemperation jackets and temperature

control arrangements. Description of the control loop used and its key elements, with reference to how the control was effected, were necessary for full marks. Many candidates, for example, did not point out that the control signal was used to adjust a flow valve, referring simply to the controller controlling temperature. Many candidates wasted time discussing the relative merits of proportional, derivative and integral control, which was not asked for.

The second part of the question was a simple heat balance calculation. Knowing that the fermenter contents cooled 3°C it was possible to determine the total amount of heat that had been removed (627,480 kJ). This would all have been transferred during the 1.75 hours taken for the process, i.e. 99,600 Js<sup>-1</sup>. At a flow rate of 3.2 kg s<sup>-1</sup> this would lead to a temperature rise of 3.89°C in the coolant.

**Question 9** (*Choosing a particular form of primary packaging, describe its basic properties. Discuss the marketing and legal implications and environmental effects of your chosen packaging. What impact might the choice of packaging type have on the properties of the beer?*)

The last question was the least popular and amongst the worst answered, with a pass rate of just 68% for the 47% of candidates attempting it. Choosing a primary package namely; bottle (e.g. returnable glass, non-returnable glass, PET), can, keg or cask, candidates were asked to describe its basic properties and relate these to marketing, environmental and legal aspects. Amongst the many properties that could have been identified for most packages were that they are: inert, sealable, strong, dark/opaque, sterilisable, recyclable/reusable, attractive, stackable, consistent size/capacity, cost effective, labellable, breakable/unbreakable, lightweight, easily transportable. Many of these properties have implications on marketing and legal issues and some have direct environmental impact.

Whilst most of the above list apply to all types of primary packaging, the effect on beer quality differs between packaging types. Complete answers included some of the following aspects as relevant: gas leakage (in and out), possibility of adding widgets, metallic taints, photodegradation, different sterilisation/pasteurisation regimes, flavour absorption.

## **Associate Membership Examination (distilling) 2001**

### **Question papers for module 1 – materials and wort**

Monday 4<sup>th</sup> June 1000 – 1300

Answer any SIX questions. All questions carry the same mark of 20

(The marks allocated to parts of questions are shown in brackets [ ] and you are strongly advised to allocate your time accordingly)

1) Describe the structure of the barley grain. [10]

Explain the role of endogenous gibberellins in the modification of the endosperm. [10]

2) Outline the operational stages involved in processing barley into malt. Explain the main aims of each stage and how these aims are achieved. [20]

3) With regard to *both* grain and malt whisky production, what are the requirements of a good quality distilling malt? [20]

4) Give an account of the mashing procedures in a typical malt whisky distillery, drawing particular attention to the procedures which maximise spirit yield. [20]

5) Discuss the advantages and disadvantages of maize, wheat and unmalted barley as cereals in the production of grain whisky. [20]

6) Discuss the methods available for the disposal, in an environmentally acceptable way, of pot ale and spent lees from malt whisky distilling. [12]

Give the typical composition of these two waste streams. [8]

7) Give a list, and a brief explanation, of the properties required in a water supply for the following purposes in whisky production:

Mashing in a malt distillery [5]

Boiler feed water in a grain distillery [4]

Boiler feed water in a malt distillery [3]

Cooling water for condensers (both types of distillery) [4]

Dilution of grain spirit for maturation [4]

8) Explain the meaning of the terms repeatability ( $r_{95}$ ) and Reproducibility ( $R_{95}$ ). [5]

Describe the basic principles enshrined in Quality Assurance concepts. [15]

### **Question papers for module 2 – yeast and beer**

1) Write detailed notes on:

(a) the principles of preserving pure stock cultures of yeasts [10]

and

(b) the practical features involved in propagating and packaging commercial pure cultures of distillers yeast. [10]

2) In a spirit still distillation, why is the foreshots fraction unsuitable for collection as spirit for maturation? [6]

In a particular distillery the cut point between spirit and feints is normally 60% alcohol by volume. Explain what would be the effects of collecting spirit to a cut point of 50% abv:

(a) deliberately, as the new standard procedure [8] and

(b) accidentally, on one isolated occasion [6]

3) Outline the available methods for detection of, and quantification of contaminant yeasts and aerobic and anaerobic bacteria on cleaned surfaces of the washback and associated pipework, and in fermenting wash. [20]

4) Name the principal structural compounds of oak wood and explain their contribution to the maturation of whisky. [20]

5) Discuss in detail how the levels in wort of assimilable amino nitrogen, molecular oxygen and metal ions will influence the progress of a distillery fermentation. [20]

6) Show as a graph the concentrations of ethanol and the principal flavour congeners in the rectifier of a continuous still for grain whisky spirit, and explain how this profile determines the level at which spirit is withdrawn from the column. [8]

What would be the effect of reducing the rate of removal of iso-amyl alcohol to the fusel oil still? [6]

What would be the effect of an increase in the alcohol concentration of the wash from 7.0 to 8.0% by volume? [6]

7) With the aid of a flowsheet diagram, explain the stages from receipt of the casks of the mature grain and malt whiskies on the premises to the start of bottling of a blended whisky. [20]

8) Describe in detail the features required for satisfactory cleaning systems for mashing and fermentation vessels in malt and grain distilleries, and cooking vessels of grain distilleries. [14]

Outline the range of appropriate materials for cleaning, and for sterilising if appropriate. [6]

### **Question papers for module 3 – process technology**

1) Explain and discuss the effect of the shape of the neck and lyne arm of a malt whisky pot still on the flavour of the spirit. [10]

What other variables affect the flavour of the spirit, and why? [10]

2) Describe the differences between laminar and turbulent flow including sketches of velocity profiles in pipes. Discuss the relevance of the two flow regimes to the liquids of the distilling industry and explain the significance of the Reynolds number in describing fluid flow. [8]

Cold wort with a density of  $1060 \text{ kg m}^{-3}$  and viscosity  $0.003 \text{ kg m}^{-1}\text{s}^{-1}$  flows down a 50 mm diameter circular pipe at a rate of  $3.5 \text{ kg s}^{-1}$ . Find the mean velocity ( $u$ ) of the wort in the pipe and determine the centre-line velocity ( $u_{CL}$ ) given that:

$u = 0.5 u_{CL}$  for laminar flow,

$u = 0.82 u_{CL}$  for turbulent flow. [6]

The wort is delivered to the washback through an outlet of 15 mm diameter (point B) which is situated 3 m above the 50 mm diameter section of the pipe (point A). If the pressure at point A is  $150 \text{ kN m}^{-2}$ , calculate, neglecting frictional effects, the pressure at the outlet. [6]

3) Draw the principal features of a 2-column continuous grain whisky still and its associated fusel oil still, showing the mass balances of all streams of the process. [20]

4) Hot condensate is collected from four points in a distillery and combined before being used in a heat

exchanger. What will be the temperature and flow rate of the combined stream if the flow rates and temperatures of the individual streams are as follows?:

- (a) 3 kg s<sup>-1</sup> at 70°C
- (b) 0.75 kg s<sup>-1</sup> at 92°C
- (c) 1.5 kg s<sup>-1</sup> at 85°C
- (d) 1.25 kg s<sup>-1</sup> at 68°C. [6]

It is proposed to use the combined stream in a counter-current heat exchanger to pre-heat a liquid from an initial temperature of 20°C to within 5°C of the combined condensate stream temperature. Calculate the heating area required. [14]

**Data:**

Specific heat capacity of all the condensate streams = 4.2 kJ kg<sup>-1</sup> K<sup>-1</sup>

Overall heat transfer coefficient of the heat exchanger = 1200 W m<sup>-2</sup> K<sup>-1</sup>

Flow rate of liquid to be pre-heated = 8 kg s<sup>-1</sup>

Specific heat capacity of liquid to be heated = 3.6 kJ kg<sup>-1</sup> K<sup>-1</sup>

5) Define convection and radiation of heat and discuss their importance in the production stages of a malt whisky distillery. [12]

Calculate the energy loss by radiation and convection from a pair of stills during their 4-hour distillation programme, with the wash still running at an average temperature of 95°C (368 K) and the spirit still at 90°C. [8]

**Data:**

Surface area of wash still = 50 m<sup>2</sup>

Surface area of spirit still = 40 m<sup>2</sup>

Stillhouse air temperature = 20°C

Stefan-Boltzmann equation:  $q_R = A\epsilon\sigma(T_1^4 - T_2^4)$

Where  $q_R$  = amount of heat transferred by radiation,

A = heat transfer area,

$T_1$  = absolute temperature of the radiating surface,

$T_2$  = absolute temperature of the receiving medium,

$\sigma$  = Stefan-Boltzmann constant =  $5.67 \times 10^{-8}$  W m<sup>-2</sup>K<sup>-4</sup>,

$\epsilon$  = emissivity ( $\epsilon$  of polished copper = 0.07 W m<sup>-2</sup>).

Air convection coefficient of polished copper surface = 5.7 W m<sup>-2</sup>K.

6) Draw, and briefly explain the function of, the essential features of the equipment for cooking grain whisky cereal at 3 barg, and for energy recovery after discharge of the cooked cereal. [12]

Calculate the energy required to cook a batch of 24 t of maize at 3 barg (140°C) in a perfectly insulated cooker. [4]

What is the total amount of water mixed with the 24 t of maize at the end of the cooking cycle but before the cooker is emptied? [4]

**Data:**

Water charge to cooker = 60 t

Feed water temperature = 85°C

Initial temperature of maize = 12°C

Specific heat of water = 4.18 kJ kg<sup>-1</sup>K<sup>-1</sup>

Specific heat of maize = 1.47 kJ kg<sup>-1</sup>K<sup>-1</sup>

Latent heat of evaporation/condensation of water at 3 barg = 2135 kJ kg<sup>-1</sup>.

7) Define the terms “stainless steel” and “Austenitic stainless steel”. [4]

Name three commonly used Austenitic stainless steel alloys and distinguish them in terms of their composition and relative cost. [8]

Describe the relevant features of stainless steels for the distilling industry. [8]

8) With the aid of appropriate diagrams, describe the processes for concentration and drying of spent wash from a grain whisky distillery into a suitable dried product for incorporation into animal feed. [20]

**Examiner’s report for modules 1, 2 & 3**

This year we had our first overseas candidates for the AME in Distilling. We welcome the participation of three candidates from Kampala, Uganda, in papers 1 and 3 but, as mentioned in the comments on specific questions, some of the information required for good marks may not have been available to these overseas candidates. This seemed to be a particular problem with paper 1. In Scotland, eleven candidates enrolled for the distilling examinations, each attempting only one module, but one of the Ugandan candidates sat two modules.

**Module 1: Materials and Wort**

Six candidates, three in Edinburgh and three in Kampala, sat this module. Questions 1 and 2, which were answered by all Distilling candidates, were the same as 1 and 2 of the Brewing paper, and the Brewing examiner’s report should be consulted for comments on the answers. Questions 3, 4 and 6 were also answered by all candidates. Only one Distilling candidate answered question 8, but that also appeared in the Brewing version of the paper and again the Brewing report should be consulted for comments on the answers.

Two of the six candidates who answered question 3 gave little more than typical (or perhaps their own company’s?) specifications of the malts for grain and malt whisky distilleries, but correct specifications gave most of the expected information on the requirements of a good distilling malt and therefore gained reasonable marks. One candidate, however, scored a very good mark by adding an explanation of each item mentioned in the specifications. The Ugandan candidates appeared to have some difficulty with this question, perhaps because of lack of familiarity with Scottish requirements.

Question 4 also caused problems for the two overseas candidates who attempted it by presenting reasonable accounts of the various mashing processes in breweries, but such answers were largely irrelevant to a question on distillery mashing. Clearly all of the Scottish candidates were very familiar with the mashing procedures in a malt distillery, but answers varied in their understanding of the reasons for the methods used. Although that did not occur to some candidates, it was expected that milling would be mentioned in the answer since no one uses whole malt grains in the mash tun. It could be argued that all steps of milling and mashing process are operated to maximise spirit yield, but some candidates sadly showed little knowledge of that relationship, e.g. in grist fractions or choice of temperatures which ensure virtually complete hydrolysis of starch.

Only two candidates answered question 5, on a comparison of the major cereals of Scotch grain whisky production. The word "discuss" implied that more was expected than tabulated analyses of the three specified cereals, although certainly that information would be an important part of the answer. It was expected that discussion would include all stages from cooking to processing of spent wash, e.g. the useful antifoam effect of the oil content of maize, and the difficulties caused by residual barley glucans on the dark grains plant.

Question 6 was an early choice well answered by all Scottish candidates. Clearly the current concern about environmental issues extends to an accurate knowledge of the composition of pot ale and spent lees. Not everyone considered spraying pot ale on farm land as fertiliser to be environmentally acceptable, although with suitable precautions there should be no accumulation of copper in the soil. Otherwise the options of aerobic or anaerobic bioplant, concentrating pot ale to syrup (usually for mixing with draff as dark grains) or discharge to sea were fully explained, including the implications of the copper content of the two waste streams. Unfortunately the two Ugandan candidates attempting this question were unaware of many of the current environmental concerns of the distilling industry in Scotland.

Question 7, on water supplies, also caused problems for the overseas candidates, although all attempted to answer it. However, the two Scottish answers showed a reasonable knowledge of the water requirements of the Distilling industry. Candidates were expected to explain the importance or otherwise in each of the specified duties of ionic composition (naming particular ions as necessary), organic content, colour, flavour/aroma and microbiological quality. The significance of the distinction between boiler feed waters of the two types of distillery is that in a grain distillery the steam used in the cookers and stills is actually incorporated in the final product and must therefore be free of flavour taint; there is no similar contact in malt distilling. The only equivalent situation which could apply in a malt distillery is the use of free steam to sterilise washbacks and is presumably negligible. Both candidates correctly noted the microbiological standards required for dilution water for spirit for maturation, since that constitutes a substantial proportion of the final product and is not sterilised by distillation.

## **Module 2: Fermentation, Distillation and Maturation**

There were five candidates, all sitting the examination in Scotland, and all answered questions 2, 4, 7 and 8. Question 1, on preparation of yeast cultures, was attempted by only one Distilling candidate. Almost identical with the equivalent question in the Brewing paper, it is discussed in that report.

Question 2 was well answered by all candidates, who were aware of the objectionable volatile congeners and the long-chain fatty acids and their esters associated with the foreshots fraction. Also, all obviously understood well the effects of longer spirit distillation on the less volatile flavour congeners in the spirit, and the delay, i.e. over at

least five successive distillations, in stabilising the system to the new conditions. All were rightly confident that the stills would quickly recover from a single mistake in distillation, as in (b). Part of the answer of one candidate could have been interpreted as suggesting that the new type of spirit was itself 50% alcohol by volume, but that was certainly not my intention. With a cut point of 50% the final strength of the spirit should be at least 63% abv, and possibly more than 65%.

Question 3, on detection and counting of microbial contaminants, was the final choice of the three candidates attempting it, and the poor to mediocre standard perhaps reflected some desperation for a sixth question they could answer. Sampling of final rinse water, or possibly swabbing the cleaned surface, and subsequent plating on malt extract or similar agar medium were correctly described for detection of contaminants on cleaned surfaces, but only one candidate mentioned alternative methods such as ATP bioluminescence. Microbiological analysis of fermenting wash is complicated by the presence of culture yeast, therefore media containing actidione are required to permit recovery of bacteria but suppress yeast growth. Candidates were expected to explain the difficulty of isolation of contaminant yeasts from a yeast culture, normally by the use of lysine agar on which *Saccharomyces* spp. cannot grow. This part, if answered at all, did not include sufficient information in any of the scripts.

Everyone showed a good knowledge of the nature of the principal structural components of oak wood, most even listing correctly the percentages of cellulose, lignin, tannins, etc. in their answer to question 4. However, candidates' subsequent explanation of their contribution to maturation of whisky was disappointing. I had hoped for more detail on the various interactions during maturation.

Question 5, on yeast metabolism, was an almost identical copy of the equivalent question in the brewing paper and is discussed above by the Brewing examiner.

There was wide variation in the quality of the three answers to question 6 on the rectification of grain whisky spirit. The best answer gave an accurate graph of the profiles of iso-amyl alcohol, butanol and propanol in the rectifier, but inclusion of acetaldehyde as well would show more clearly the reason for the distance of the spirit plate from the top of the column. For the second and third parts of the question, an increase in iso-amyl alcohol in the lower levels of the rectifier is known to displace ethanol upwards, therefore less efficient rectification is achieved over the smaller number of plates which are still functioning. A similar effect results from increased strength of wash: higher alcohol strength means less efficient separation of congeners over the whole height of the column.

All candidates showed themselves to be sufficiently familiar with blending plant to give a good account of the succession of processes leading up to bottling, although in some answers to question 7 more detail would have been appreciated, e.g. on pore sizes of filters and typical temperatures of cooling units. Also, one candidate lost marks by forgetting the rather important filtration stage between chilling and the return of the whisky to ambient

temperature, and another by largely ignoring the request to explain (briefly would have been enough) each stage of the flow diagram.

Question 8 on cleaning and sterilisation of process vessels was also competently handled with evidence of practical experience by the majority of candidates. The word "features" was used to encourage candidates to include structural standards in the answer, e.g. for stainless steel vessels, smooth joints, rounded corners and good drainage. One important aspect of the answer was the distinction between (a) the mash tun and cereal cooker, which require chemical and physical cleanliness only, and (b) the washbacks, which should be as close to sterility as possible. One candidate included a competent and detailed description of cleaning and sterilisation of pipework and pumps, but since that had not been included in the question, scored no marks for that part of the answer. So, as general advice, reading and understanding the question can be very effective in gaining marks, or at least not wasting time and effort on irrelevant information.

### Module 3: Process Technology

Only three candidates, two in Edinburgh and one in Kampala, sat the examination. All answered questions 1, 2, 3 and 5. Questions 2, 4 and 7 were shared with the Brewing paper and the Brewing examiner's report should be consulted for comments on these answers.

Especially in the context of an engineering examination, the reflux effects in the stills are an important part of the relationship between still geometry and spirit flavour. The first part of question 1 sought a discussion on the effect of the shape of the still on reflux, and therefore on the amount of flavour congeners reaching the distillate. This is particularly important with congeners of lower volatility than ethanol. Many of the "other variables" of the second half of the question would also concern reflux, and hence the flavour of the distillate, e.g. rate of distillation, but the foreshots/spirit/feints cut points should also have been identified as important. One of the candidates produced a most impressive list of all the factors which could possibly affect distillation of flavour congeners: not only the expected distillation variables, but also, perfectly legitimately, including effects of fermentation and wash strength.

As well as a neat and accurate drawing of the principal features of a continuous still as the answer to question 3, relative amounts of wash, steam, alcohol and spent wash, and various intermediate streams such as hot spirit vapour, should have been indicated, e.g. expressed in proportion to 100 units of wash. While these figures may not be easily available in the literature, it should be possible with a reasonable knowledge of the process to estimate them. Therefore marks varied considerably according to quality of draughtsmanship and the inclusion of numerical values.

Although the calculation forming the second part of question 5 concerned only distillation, the first part of the answer required an explanation of all the important heat losses in malt distilleries. The most obvious losses are associated with storage of mashing water, mashing itself, the (presumably beneficial) heat losses from stills and, for completeness, unlagged pipes.

The first part of question 6, answered by only one candidate, required a drawing of the cooker and its important ancillary equipment. The steam supply had to be explained: it is impossible to take the intermittent heavy load of cooking steam from the boiler supplying the stills without de-stabilising their operation. Therefore a reservoir of high-pressure hot water ("accumulator") is essential. The system for recovery of heat energy by flashing off steam after cooking was also an important part of the drawing.

Although the resulting foul condensate is an important effluent consideration, that did not have to be mentioned in the context of energy aspects of the process. The calculation is simple (hence only 4 marks per section!) provided it is realised that there is no evaporation of water until the cooking cycle is completed and the vessel is discharged: in the pressurised cooker the water, although at 140°C remains liquid. The value of latent heat of condensation of water at 3 bar was given only to calculate the amount of steam condensing in the cooker and adding an additional 8.6 t (or more accurately, 8576 kg) to the cooked mash.

Fortunately neither of the two candidates answering question 8 decided on a review of all possible processes which could be used for concentration and drying of spent wash. They sensibly chose only one plausible sequence of processes for centrifugation and subsequent concentration and drying of the separated streams for illustration and written explanation.

### Diploma Master Brewer Examination 2001

#### Question papers for module 1 – materials and wort production

Monday 4th June 1000 – 1300

Answer any FIVE questions. All questions carry the same mark of 20

- 1) You have been asked to undertake a quality audit on a maltings you have never visited before. Draw up an audit check list and explain in detail the significance of each item on your list. [20]
- 2) Many parameters have been used to describe the attributes of good quality malt. Which do you consider to be the eight most important? Explain why these parameters are at the top of your list for the malt purchased for your brewery. [20]
- 3) Raw water at your brewery is high in nitrate and bicarbonate. Specify the plant you would install to prepare water suitable for brewing, cleaning-in-place and beer dilution. What extra treatment would you carry out on water for beer dilution? [20]
- 4) Hops may be used to bring diverse flavour and aroma characteristics to different styles of beer. Describe the various ways you can use hops to achieve this diversity and explain the significance of the different varieties of hops at your disposal. [20]
- 5) Estimate the annual brewing materials requirements to produce:

1,500,000 (one million five hundred thousand) hectolitres of 5.2% alcohol by volume lager beer using 80% malted barley.

\* 75% of the volume is packaged into 500 ml cans and the rest into 30 litre kegs.

\* This beer has a bitterness of 30 BU.

Specify the batch size and brewing frequency for the wort production stage of this beer; state all your assumptions and show all calculations. [20]

6) A range of industrially produced enzymes is available to the brewer for use in the brewhouse. Describe the main products available, how and why they are used and include the benefits and the shortcomings associated with their use. [20]

7) Describe, including the benefits and drawbacks, the various devices available for separating spent hop material and trub from wort at the end of the kettle boil. Why is this process important and how would you monitor cold wort quality to ensure that it has been carried out successfully? [20]

8) Your new manager would like to see a marked improvement in extract yield and energy consumption in the brewhouse. Outline some of the measures you could take to achieve these aims and discuss the risks to product quality that such measures might introduce. [20]

#### **Examiner's report for module 1 – materials and wort production**

There were 40 candidates registered for this examination, although only 37 papers were returned. 25 (68%) candidates achieved a pass mark. This success rate should be compared with previous years' results, 2000 (68%), 1999 (74%), 1998 (57%), 1997 (69%) and 1996 (65%).

The overall pass rate was marginally ahead of the average. There were several good papers submitted and one very good paper. There was a surprising amount of inconsistency within individual papers with some questions being answered very competently whilst others were answered very sketchily.

As in previous years there were several candidates who were clearly very badly prepared and should not have been sitting the exam. Several candidates obviously ran out of time and answered their final question very badly; one candidate in particular answered four questions extremely well, but obtained a very low mark on the fifth and final answer. That candidate would have gained a very high pass mark had the final question been answered with the same competence as the first four.

**Question 1** (*You have been asked to undertake a quality audit on a maltings you have never visited before. Draw up an audit check list and explain in detail the significance of each item on your list.*)

This question was attempted by 19 (51%) of candidates with 14 (74%) achieving a pass mark. On the whole this question was answered much better than the question on malting plant design which came up last year. Candidates were much better acquainted with the malting

process and identified the critical points to be checked on. Discussion of topics not strictly under the heading of 'quality' such as personnel issues, training, housekeeping, health and safety and environmental concerns were ignored by many candidates.

A good answer would have described the malting process in terms of the critical points in the process that require examination and the significance of each critical point would have been explained. Other areas such as operators' training records and training plans, as well as health and safety awareness and environmental concerns, gained extra marks.

**Question 2** (*Many parameters have been used to describe the attributes of good quality malt. Which do you consider to be the eight most important? Explain why these parameters are at the top of your list for the malt purchased for your brewery.*)

This was the most popular question of the paper: it was attempted by 31 (84%) of the candidates, with 25 (81%) achieving a pass mark.

In general it was well answered and many candidates gained good marks here. Some candidates proffered more malt specifications than the question requested; these were ignored and no extra marks were gained.

There was a tendency to select specifications that in essence all measured the same characteristic. Modification was a good example with some candidates excluding important specifications such as colour, moisture and extract in favour of yet another specification measuring modification.

A good answer would have included a broad selection of parameters with explanations as to the importance that the candidate attached especially in their brewery setting.

**Question 3** (*Raw water at your brewery is high in nitrate and bicarbonate. Specify the plant you would install to prepare water suitable for brewing, cleaning-in-place and beer dilution. What extra treatment would you carry out on water for beer dilution?*)

This question was attempted by 23 (62%) of candidates with 10 (43%) achieving a pass mark. This was an easy question badly answered. A disappointing result – which is more surprising when taking into account the central importance of a satisfactory water supply for brewing, process purposes and dilution. Many candidates failed to justify their choice of treatment with a surprising number opting for total de-ionisation rather than reverse osmosis. In their particular situation this is possibly the correct choice, but some discussion of the implications, especially effluent, must be made. Other candidates failed to discuss the implications for the brewing process of nitrate and bicarbonate, others were unable to draw their selected plant adequately, whilst many forgot the need add back some salts to prepare the water for brewing and the requirements of de-aerated liquor for dilution purposes.

A good answer would have explained the background implications of nitrate and bicarbonate, listed the various options with pros and cons (a tabular format would have been useful here) followed by a discussion of which plant would be most appropriate in the candidate's situation, and why. Further detail about what treatment would be appropriate for water used in CIP and dilution operations

as well as the extra treatment required to de-aerate water should have been included.

A better answer would have included some of the QC measures required to ensure correctness and consistency for each application.

**Question 4** (*Hops may be used to bring diverse flavour and aroma characteristics to different styles of beer. Describe the various ways you can use hops to achieve this diversity and explain the significance of the different varieties of hops at your disposal.*)

This question was attempted by 23 (62%) candidates with 12 (52%) achieving a pass mark. Hops are a critical raw material that bring flavour and diversity to beer, so it is always surprising that the hop question is so badly answered each year. Some candidates had taken heed of remarks in previous years' examination reports and produced some very good answers.

A good answer would have included a discussion of the significance of alpha acid levels of different hop varieties, an explanation of the classification of aroma, high alpha and dual-purpose varieties. This should have led to a discussion about varieties and their differences to include flavour, aroma, agronomic factors and cultivation. The use of whole cone hops, pellets, extracts and isomerised preparations should have been discussed. A better answer would have included the significance of late hopping and dry hopping, and the use of reduced hop extracts for foam enhancement and prevention of light-struck flavours.

**Question 5** (*Estimate the annual brewing materials...*)

This question was attempted by 25 (68%) candidates with 22 (88%) achieving a pass mark. In general this question was well answered though the mathematics were often badly laid out and difficult to decipher. The usual schoolboy howlers of taking losses into account by, for example, multiplying the packaged volume by 1.04 to calculate the volume of bright beer required with a packaging loss of 4%, were made. The correct mathematics would be to divide the packaged volume by 0.96. Adding together loss percentages at individual process stages to calculate an overall loss is also incorrect. Many of the calculations of the hop grist were equally difficult to follow logically, though usually the final answer was correct. There was a lot of woolly thinking about the batch size requirements, with many candidates using the batch size of their own brewery, which often led to some curious plant utilisation. Some discussion about anomalous utilisation should have ensued.

A good answer would have laid out the assumptions and values used in the calculation and shown a clear logical calculation path for the annual requirements for malt, sugar/adjuncts and hop/hop products. The batch size calculations should have been appropriate to the annual volume and include seasonality and maintenance requirements where appropriate.

**Question 6** (*A range of industrially produced enzymes is available to the brewer for use in the brewhouse. Describe the main products available, how and why they are used and include the benefits and the shortcomings associated with their use.*)

Only 6 (16%) of candidates attempted this question with 2 (33%) gaining a pass mark. Undoubtedly the worst answered question of the entire paper.

Most of those who attempted it only managed to discuss one, or two at the most, enzyme categories, and were very shaky about their activity and use.

A good answer would have included a brief description of the enzymes which are naturally present during mash conversion followed by how individual enzymes such as amylase, amyloglucosidase, pullulanase,  $\beta$ -glucanase and proteinase, as well as commercially available mixtures of them could be used in high adjunct-level brewing or barley brewing, or to improve extract recovery or wort run-off. A better answer would have explored the cost benefits and disadvantages of their use.

**Question 7** (*Describe, including the benefits and drawbacks, the various devices available for separating spent hop material and trub from wort at the end of the kettle boil. Why is this process important and how would you monitor cold wort quality to ensure that it has been carried out successfully?*)

This question was attempted by 22 (59%) of candidates with 14 (64%) obtaining a pass mark. There were some good answers to this question but far fewer than might have been anticipated. Most candidates were familiar with the whirlpool, several mentioned the hop back, surprisingly few discussed the use of the decanter and disc centrifuge. The significance of obtaining bright worts prior to fermentation seemed to pass by many candidates, as did methods for evaluating and monitoring wort quality.

A good answer would have included a list of devices available along with their pros and cons, probably in tabular form, along with some sketch drawings to illustrate the comments. A discussion of the effect of excess protein/polyphenol on fermentation performance, and finished beer clarification and flavour, and, haze stability, would be followed by techniques for monitoring wort, both hot and cold. Extra marks could be obtained by mentioning the use of copper finings as these are involved in the coagulation of unwanted wort protein.

**Question 8** (*Your new manager would like to see a marked improvement in extract yield and energy consumption in the brewhouse. Outline some of the measures you could take to achieve these aims and discuss the risks to product quality that such measures might introduce.*)

This question was attempted by 29 (78%) of candidates with 22 (76%) gaining a pass mark.

There were some very good and some very bad answers to this question. Here is an opportunity to examine the malt handling plant and brewhouse in great detail from malt deliveries to wort at the cold wort heat exchanger. The better candidates spotted this opportunity to assess all the weak spots in the process where valuable material can leak away and contribute to poor extract performance. However, some candidates imagined their new manager appearing in the guise of John Paul Getty with an infinitely long chequebook. They were prepared to throw out a perfectly satisfactory lauter tun in favour of

a mash filter to gain 2 or 3% increased extract performance.

Whilst situations undoubtedly arise where capital expenditure is both appropriate and timely, the real answer to this question was about attention to detail and a willingness to explore the process with an open mind.

The energy saving measures clearly need a discussion about kettle boiling vigour and times and the risks inherent in any proposed changes, as well as again, attention to the little details.

A good answer would have included some of the team-working initiatives that could be introduced to tackle some of these aspects.

### **Question papers for module 2 – fermentation and beer processing**

Monday 4<sup>th</sup> June 1400 – 1700

Answer any FIVE questions. All questions carry the same mark of 20.

1) Compare and contrast the various means available for controlling the amount of yeast added to wort. Describe briefly how you would check the actual results achieved.

How would you rectify problems of inconsistent fermentation performance in a brewery where the quantities of yeast pitched are routinely within the target band?

2) In order to increase capacity, it has been decided to increase the brewed gravity of your top selling lager brand from 1058° (14.5 P) to 1075° (18.75 P) by the use of a high maltose brewing syrup. Discuss the possible issues arising from this decision in fermentation and downstream processing, and propose suitable solutions.

3) Discuss the relative merits of single-use systems and reclaim systems for the cleaning in place (CIP) of Fermentation Vessels (FVs) and Bright Beer Tanks.

Describe the monitoring and control systems you would adopt to ensure effective cleaning takes place consistently when cleaning FVs, fitted with rotary spray jets, with the system of your choice.

4) Sample Room reports indicate that canned and bottled beer is showing non-biological haze failures well before the end of its usual shelf life. Discuss possible causes for this problem originating from fermentation onwards. What procedures would you adopt to overcome this problem and prevent its recurrence?

Discuss the relative merits of the laboratory-based methods for predicting shelf life that you may choose to employ.

5) Your Packaging colleagues have become concerned recently about the down time they have incurred waiting for beer from Bright Beer Tank (BBT) due to failures to meet targets for CO<sub>2</sub>, dissolved oxygen and alcohol-by-volume (ABV). What plant, processes and procedures would you introduce downstream of the conditioning tank to rectify this situation and achieve >95% right first time for these parameters?

Which other parameters would you use for positive release of beer from BBT? Explain your reasoning.

6) Recent laboratory reports indicate an increasing level of both aerobic and anaerobic organisms present in beer in Bright Beer Tank. Describe how you would determine the source(s) of this infection and the measures you would take to eliminate it. Include in your answer a brief description of the microbiological tests you would employ.

7) You have been asked to put together a proposal for capital equipment to increase filtration capacity from 2 to 2.8 million hl. per year. All the extra production will be small pack beer requiring 9 months shelf life, and all the current plant is fully utilised. With the use of appropriate diagrams, specify and justify the new plant and equipment you would recommend.

What additional utilities and services would be required to support the new plant?

8) Your company has seconded you to a recently acquired brewery that has no formal loss control system, but it is thought that losses between Fermentation Vessel and Bright Beer Tank are running at 6.5%. Describe the actions you would take, including any plant, equipment and systems you would introduce, to establish the true picture. How would you improve the loss performance and what targets would you set at each stage of the process?

### **Examiner's report for module 2 – fermentation and beer processing**

Thirty six candidates submitted scripts for the paper. Twenty four gained pass grades, a pass rate of 67% which is significantly improved over last year. There were three good papers at grade B, and eight at grade C. There were several candidates who scored well in two or three questions and struggled in the remainder, perhaps confirming the recent evidence of a narrowing of the range of experience and knowledge amongst entrants. Six candidates failed significantly to tackle this paper in the depth required.

There were some areas of examination technique that let people down. Several papers showed clear evidence of the last one or two answers being rushed in note form or barely even started, whereas earlier answers had been over-elaborate. In a few cases candidates had failed to read the question fully and produced incomplete or irrelevant answers. Occasionally, handwriting or diagrams were so poor that marks could not be awarded for certain passages. Candidates should also take care to answer the question in the way signalled – i.e. when asked for “discussion” or “describe in detail”, then do just that, and save the brief notes for questions that ask for them.

**Question 1** (*Compare and contrast the various means available for controlling the amount of yeast added to wort. Describe briefly how you would check the actual results achieved.*)

25 candidates attempted this question with 20 passing (80%).

Most answers demonstrated a knowledge of pitching systems using off-line measurements of viability and solids levels coupled with pumping using volume or mass flow meters or load cells. All had at least heard of the capacitance probe systems to control the amount of live cells pumped past it, but there were several accounts clearly related from hearsay with some fanciful descriptions of the principle behind it. Too many people described *measuring* systems and stopped short of saying how the measurements were used to *control* the process, thereby failing to score more heavily. Many people suggested yeast counts using a haemocytometer as a means of checking success, but few went further to consider electronic particle counters and other classic microbiological methods. Despite the rather heavy hint in the second part of the question, a large number of candidates “verified” their achievement of the correct pitching rates by the resulting fermentation performance!

Many answers to the second part, which was worth a similar mark to the first part, considered the relevant effects of wort composition in this context such as dissolved oxygen and zinc levels, and the aspects of yeast handling and storage relating to vitality were often well reviewed. More complete answers contained reference to temperature control, selective cropping, the generation effect and contamination.

**Question 2** (*In order to increase capacity, it has been decided to increase the brewed gravity of your top selling lager brand from 1058° (14.5 P) to 1075° (18.75 P) by the use of a high maltose brewing syrup. Discuss the possible issues arising from this decision in fermentation and downstream processing, and propose suitable solutions.*)

17 candidates attempted this question with 8 passing (47%).

Ideal answers would have contained a summary of the effects of the new wort composition such as increased osmotic pressure, higher ABV after fermentation, reduced FAN and modified sugar and ionic profile. This should then be followed up with a description of the issues arising such as fermentation profile, yeast stress, flavour differences, etc. Several candidates then failed to identify solutions to these issues, preferring instead to accept them as consequences of the need for capacity increase. Better answers contained remedies such as increasing wort oxygen and zinc levels, modifying temperature profiles, monitoring diacetyl profiles and adjusting maturation times or temperatures, and improving yeast handling procedures.

The downstream effects such as the need for extra blending liquor flow rates, the higher cost associated with losses and the possible need to increase head additive rates to address a potential decline in foam performance should all have been considered. The process of minimising the impact of flavour changes through process condition changes, trial brewing and tasting, and introductory blending programmes gained top marks for the few who considered it.

**Question 3** (*Discuss the relative merits of single-use systems and reclaim systems for the cleaning in place (CIP) of Fermentation Vessels (FVs) and Bright Beer Tanks. Describe the monitoring and control systems you*

*would adopt to ensure effective cleaning takes place consistently when cleaning FVs, fitted with rotary spray jets, with the system of your choice.*)

33 candidates attempted this question with 23 passing (70%).

This was the most popular question on the paper and a good pass rate was achieved, but there was a wide range of quality of answers. Several candidates equated single-use systems with portable tanks and manually-positioned spray jets and appeared not to appreciate the availability of automated circuits fed from fixed tanks of chemicals and a water balance tank. Aspects of discussion should have included usage strength and rates of chemicals, different impacts on effluent levels, effect on energy usage if warm cleaning is used, relative costs of purchase, degrees of automation possible and capability to clean multiple vessels simultaneously.

The second part of the question was worth 30% of the marks but too many answers confined the discussion to the cleaning plant controls only (such as conductivity, temperature, pressure and flow controls, route proving, etc.) and failed to include monitoring the outcomes of cleaning such as rinse water examination, plant swabs and subsequent beer infection levels.

**Question 4** (*Sample Room reports indicate that canned and bottled beer is showing non-biological haze failures well before the end of its usual shelf life. Discuss possible causes for this problem originating from fermentation onwards. What procedures would you adopt to overcome this problem and prevent its recurrence? Discuss the relative merits of the laboratory-based methods for predicting shelf life that you may choose to employ.*)

22 candidates attempted this question with 6 passing (27%).

A fairly popular question but with a low average mark and pass rate. Many answers contained a basic review of protein-polyphenol hazes and a few key points relating to minimising their persistence. Several candidates failed to distinguish causes of instant haze problems in bright beer with those relating to hazes forming in package months later. Better answers reviewed the impact of temperature during cold-storage and filtration, dissolved oxygen and metal ions. Discussion of the use of processing aids such as PVPP, silica hydrogel, etc. should have considered dose rates, regeneration efficiency, contact time, etc.

Very few answers to the second part, worth 25% of the marks, mentioned any test other than accelerated ageing, and even here the times and temperatures suggested varied widely. A complete answer would in addition have considered “instant” tests aimed at detecting potential haze components such as polyphenols, tannoids and sensitive proteins, and reviewed their advantages and limitations compared to accelerated heat forcing or temperature cycling tests.

**Question 5** (*Your Packaging colleagues have become concerned recently about the down time they have incurred waiting for beer from Bright Beer Tank (BBT) due to failures to meet targets for CO<sub>2</sub>, dissolved oxygen and alcohol-by-volume (ABV). What plant, processes and*

*procedures would you introduce downstream of the conditioning tank to rectify this situation and achieve >95% right first time for these parameters? Which other parameters would you use for positive release of beer from BBT? Explain your reasoning.)*

23 candidates attempted this question with 14 passing (61%).

This question was seeking understanding of all aspects of the process from conditioning tank, through filtration up to and including BBT that could affect the control of three important quality parameters. Too many answers considered only in-line control instrumentation in the filter room itself, thereby restricting the scope of marks available. Better answers contained reference to pressure and flow conditions throughout, actual results in CT and plant capability to deliver the dilution rate or CO<sub>2</sub> injection rate. As in question 1, some candidates suggested merely measuring DO<sub>2</sub> in line effected control, and failed to consider the procedures necessary to deaerate mains, provide inert atmospheres in buffer tanks and BBTs, fix leaking pump seals and valves, etc. There should also have been consideration of ensuring robust procedures are in place, audits to ensure they are followed, calibration and maintenance is done as required, and operator training is adequate.

The follow-up question asked which other parameters should be considered for positive release from BBT, and why, and was worth 25% of the marks. Palate, OG, haze, pH and colour were the most popular choices, while more complete answers considered head properties, bitterness and a stability check such as polyphenols for long shelf-life products. Some of the reasoning behind the choices was thin, and should have included consideration of consumer impact and parameters likely to be affected by the process at this stage, balanced with sensible resource availability to do the tests.

**Question 6** (*Recent laboratory reports indicate an increasing level of both aerobic and anaerobic organisms present in beer in Bright Beer Tank. Describe how you would determine the source(s) of this infection and the measures you would take to eliminate it. Include in your answer a brief description of the microbiological tests you would employ.*)

19 candidates attempted this question with 12 passing (63%).

Several answers went straight into solving the problem by assuming it was a CIP problem in BBT without diagnosing the source of the infection through a troubleshooting approach and series of microbiological samples at all stages of the process. Of those who did adopt this more logical approach, some confined their approach to the main beer stream and ignored additions, gases and other potential sources. Several good answers considered CIP cycle reviews, chemical changes, temporary increase in strength or use of hypochlorite or extra hot cleaning, and also considered the procedures for sterilisation of blending liquor and gases and the plant associated with other additions such as filter aids.

There was again a poor understanding of the microbiological laboratory tests asked for in the follow-up

question, worth 20% of the marks. What was required was brief notes on plant swabs and rinse liquor checks (both traditional and using rapid detection), and on beer tests on both rough and bright beer using aerobic plates and anaerobic media.

**Question 7** (*You have been asked to put together a proposal for capital equipment to increase filtration capacity from 2 to 2.8 million hl. per year. All the extra production will be small pack beer requiring 9 months shelf life, and all the current plant is fully utilised. With the use of appropriate diagrams, specify and justify the new plant and equipment you would recommend. What additional utilities and services would be required to support the new plant?)*

14 candidates attempted this question with 5 passing (36%).

Once again the knowledge of filtration plant appears to be limited amongst candidates, as this was the least popular question and had the lowest pass-rate. Sizing of the plant should have taken into account seasonal factors, weekly manned hours, high gravity dilution factor, etc. Most candidates opted for a new single-stream plant, though answers involving extending existing plate and frame machines and building new, fully automated plants to do the whole volume and reduce manning were equally valid. However, few answers contained a complete description or full diagram of the layout or the requested justification for the major items, and many failed to include buffer tanks, chiller, or carbonator amongst others.

Many answers to the follow-up item on provision of extra utilities and services, worth 20% of the marks, gave a brief and incomplete list, showing a narrow appreciation of the topic. Some answers contained a comprehensive list and top marks were gained by those (few) who quantified the major elements such as electricity, refrigeration and liquor usage.

**Question 8** (*Your company has seconded you to a recently acquired brewery that has no formal loss control system, but it is thought that losses between Fermentation Vessel and Bright Beer Tank are running at 6.5%. Describe the actions you would take, including any plant, equipment and systems you would introduce, to establish the true picture. How would you improve the loss performance and what targets would you set at each stage of the process?)*

25 candidates attempted this question with 19 passing (76%).

A popular question with a high pass rate. Most candidates illustrated how to set up a loss measurement and control system adequately, though better answers had a more detailed review of static vessel contents measurement and in-line metering for main stream beer, yeast crops, blending water and additions. Process flow charts and tables were useful aids to delivering a good answer.

Having established a measuring system, the better answers worked systematically through the process and described techniques such as how yeast growth can be minimised through dissolved oxygen and pitching rate

control; losses through fobbing in FV could be controlled by pressure, fill-height, temperature or antifoam; improved crop and bottoms removal and recovery of beer from them can increase yield; the use of first and last runnings and better planning of filter runs; control of CO<sub>2</sub> and DO<sub>2</sub> to avoid gas-washing in BBT. Overall target figures given were largely acceptable in the 3 – 4.5% range, but some of the breakdown figures between different parts of the process were difficult to reconcile.

### **Question papers for module 3 – packaging and beer dispense**

Tuesday 5<sup>th</sup> June 1000 – 1300

Answer any FIVE questions. All questions carry the same mark of 20.

- 1) Describe in detail the principles leading to EITHER:
  - a) effective flash (bulk) pasteurisation and keg cleanlinessOR
  - b) returnable bottle cleanliness and effective tunnel pasteurisation of returnable bottles.
  
- 2) Your company is to amalgamate two bottling lines from different sites into one new facility. The current facilities operate on a 2 × 8 hour shift, 5 days per week system. Current annual volumes are:  
Site A: 250 000 hectolitres in 500 ml returnable bottles packed in 12's in crates  
*and*  
150 000 hectolitres in 330 ml non-returnable bottles packed in 24's in cartons  
Site B: 100 000 hectolitres in 330 ml non-returnable bottles packed in 24's in cartons  
*and*  
300 000 hectolitres in 330 ml non-returnable bottles packed in multipacks of 4's and 6's shrink-wrapped in a tray.  
Assume no change in product mix or volume.  
Identify the plant with appropriate outputs which you would need in the new facility.  
On what basis would you decide whether existing plant should be reused or replaced?
  
- 3) For *either* a bottling line *or* a canning line identify the laboratory analyses and process measurements you would make to assure the quality of the final packaged product.  
State which of these process parameters are suitable for automated process measurement and control.  
Using the control of oxygen in packaged product as an example describe how you would manage data to facilitate immediate corrective action, short term troubleshooting, and on-going process improvement. [20]
  
- 4) Your large pack (cask or keg) line currently works a 2 by 8 hour shift system, (5 days a week), with overtime required periodically.  
Draw up a list of possible cost saving measures.  
Describe with examples, how you would evaluate these potential measures. You should include both procedural and capital solutions. [20]

5) You operate a small pack (bottle or can) line and have a system for monitoring consumer complaints.

For foreign bodies AND off-flavour complaints draw up a procedure for evaluating and rectifying issues arising from these complaints. Illustrate the working of the procedures with examples. [20]

6) Write a specification for dispense of draught beer. You should include both dispensing and in-glass parameters.

What design features and operating conditions in the cellar and dispense area will ensure the specification is met? [20]

7) Contrast the relative advantages and disadvantages of any TWO of the following:

- a) Aseptic filling versus tunnel pasteurisation
- b) Lightweight glass versus P.E.T. bottles
- c) Rotary keg washer/fillers versus in line keg washer/fillers
- d) Filler versus pasteuriser as the key determinant for packaging line design and efficiency calculations. [20]

8) Your packaging line is being audited by a major customer:

Detail which principles you would highlight in order to provide evidence that your process is under control. Your answer should cover the following areas: product integrity, health and safety, product quality, and continuity of supply. [20]

### **Examiner's report for module 3 – packaging and beer dispense**

In 2001, 47 candidates sat the examination of whom 21 (45%) achieved the pass standard. This represents a lower percentage than last year more in line with the previous two years.

Despite the lower pass rate it was pleasing to note that two candidates achieved passes with B grades.

Poor answers dealt with the questions in very general terms, whilst conversely, good answers showed the candidate's familiarity with the process through the inclusion of sensible process values and insight gained through experience.

In general those candidates who reached the pass standard were able to give good answers across a range of questions whilst those failing to reach the standard often could answer well in only one or two areas.

Again examination technique could have helped some of the candidates by focussing on the question asked rather than answering with a general discussion of the topic.

**Question 1** (*Describe in detail the principles leading to EITHER: a) effective flash (bulk) pasteurisation and keg cleanliness OR b) returnable bottle cleanliness and effective tunnel pasteurisation of returnable bottles.*)

This was the most popular question with 41 (87%) [21 a) and 20 b)] candidates answering of whom 27 (66%) achieved a pass mark. Answers ranged from the very poor to excellent with one in particular being almost perfect. There was a significant proportion of good passes.

Though not specifically required, for both sections a) and b), clear, annotated diagrams were a good way to pick up marks efficiently.

Flash pasteurisation (12 marks) - good answers were able to explain the importance of time, temperature and pressure, give sensible values and explain how the process is controlled. Heat exchange, fouling, start-up and recirculation procedures all gained marks. Poor answers were restricted to a general description of the theory of pasteurisation.

Keg cleanliness (8 marks) - poor answers were restricted to noting the importance of temperature and detergent with a generalised cleaning regime. Good answers were able to deal with internal and external cleaning quoting times and temperatures, materials and strengths. Cleaning action was described along with clear cycle regimes.

Bottle washing (10 marks) - as with keg cleanliness poor answers were restricted to a general description of the importance of temperature and caustic and a rough description of a bottle washer. Good answers again included sensible temperatures for the various baths, caustic strengths and reasons for the use of additives. A clear process flow with reasons for the various stages picked up good marks.

Tunnel pasteurisation (10 marks) - as with keg pasteurisation good marks were awarded for answers which included sensible values for time and temperature with reasons. Further marks were gained for an understanding of water balance, treatment and pressure, quenching procedures and process control.

**Question 2** (*Your company is to amalgamate two bottling lines from different sites into one new facility...*)

This variation of a fairly standard question was answered by 25 (53%) candidates of whom 14 (56%) achieved a pass. A wide range of standards of answer was received.

Poorer answers completely ignored the existing lines and merely designed a new line for the new production requirement. Good answers noted that one existing line could cope with more shifts/investment or doubling up on key equipment with the same shift pattern might work. Sizing of the new line needed to take account of seasonality, lost time/days and brand/size changes. Plant requirements (diagram useful) with sizing and identification of re-used equipment coupled with sensible rationale for re-use (including age/condition, capital/refurbishment/moving cost, quality, efficiency, sizing) completed good answers.

**Question 3** (*For either a bottling line or a canning line identify the laboratory analyses and process measurements you would make to assure the quality of the final packaged product. State which of these process parameters are suitable for automated process measurement and control. Using the control of oxygen in packaged product as an example describe how you would manage data to facilitate immediate corrective action, short term troubleshooting, and on-going process improvement.*)

A moderately popular question with 32 (68%) candidates answering and 19 (59%) achieving the pass

standard. Most answers were around the pass mark with only a few very poor/very good answers.

Laboratory analysis tended to focus on beer analysis, excluding packaging and process materials. Process analyses were usually reasonably covered with variable responses to the automation part.

The management of oxygen analysis data for which there were 9 marks was usually poorly answered with immediate action, short-term troubleshooting and long term improvement often approached with a single list of things to check when oxygen is high.

**Question 4** (*Your large pack (cask or keg) line currently works a 2 by 8 hour shift system, (5 days a week), with overtime required periodically. Draw up a list of possible cost saving measures. Describe with examples, how you would evaluate these potential measures. You should include both procedural and capital solutions.*)

Along with question 5 this was the least popular question with 17 (36%) candidates answering and the most poorly answered with 4 (24%) achieving a pass.

Poorer answers gave a short list of possible measures with little or no description of how to evaluate their proposals. Good answers looked at a variety of cost elements in a packaging department budget, detailed how to measure performance against budget and how to evaluate potential changes (e.g. payback on capital, trial processes, cost/man, cost/hL).

**Question 5** (*You operate a small pack (bottle or can) line and have a system for monitoring consumer complaints. For foreign bodies AND off-flavour complaints draw up a procedure for evaluating and rectifying issues arising from these complaints. Illustrate the working of the procedures with examples.*)

Of the 17 (36%) of candidates who tackled this question, it was well answered with 11 (65%) passing.

Good answers logically described a procedure which dealt with receipt, communication, traceability, sample handling/analysis, severity, data analysis, cause hypothesis and testing through to corrective action (10 marks). Sensible examples made up the remaining marks (10).

**Question 6** (*Write a specification for dispense of draught beer. You should include both dispensing and in-glass parameters. What design features and operating conditions in the cellar and dispense area will ensure the specification is met?*)

This was the second most popular question with 35 (74%) candidates answering of whom 16 (46%) achieved the pass standard.

In the section on specification (8 marks) reasonable numbers for targets related to a given product type were required. Parameters looked for included dispense time, temperature, quantity and fobbing and in-glass foam/seeding, clarity and flavour. Good answers then related specifics of cellar/dispense area design and operation to the specification described. Poor answers merely described a cellar installation with many features of limited relevance to the specification (lighting, floor materials) and with no attempt to relate the design elements back to the dispense specification.

**Question 7** (*Contrast the relative advantages and disadvantages of any TWO of the following: a) Aseptic filling versus tunnel pasteurisation, b) Lightweight glass versus P.E.T. bottles, c) Rotary keg washer/fillers versus in line keg washer/fillers, d) Filler versus pasteuriser as the key determinant for packaging line design and efficiency calculations.*)

This question was answered by 33 (70%) candidates of whom 15 (45%) achieved the pass standard. There was a wide spread in the standard of answers from the very poor to the very good.

- Aseptic filling vs. pasteurisation (31 answers). Good answers went beyond the microbiological risks and flavour impact to consider other issues such as capital and revenue costs, speed and efficiency and environmental impact.
- Glass vs. PET (5 answers). Good answers included the challenges of using PET including barrier properties, consumer attitude, speed and efficiency as well as the benefits such as safety and weight. Also considered were lightweight glass risks including material control and handling.
- Rotary vs. in-line keg fillers (17 answers). There was plenty of opportunity to discuss differences here including costs, efficiencies, speeds, space, noise, manning and flexibility.
- V-curve (13 answers). This was poorly answered. A good answer would include evidence of background knowledge discussing the risks of driving the process from the two points. Discussion could include oxygen vs. PU control, line cost, flexibility, and utilisation.

**Question 8** (*Your packaging line is being audited by a major customer: Detail which principles you would highlight in order to provide evidence that your process is under control. Your answer should cover the following areas: product integrity, health and safety, product quality, and continuity of supply.*)

This question was answered by 33 (70%) candidates with 17 (52%) achieving the pass standard. There were two excellent answers whilst the remainder were centred closely around the pass mark.

This question was looking for an appreciation of the focus of external customers. The four areas (5 marks each) were each dealt with varying success. For product integrity a HACCP style approach with examples was required. Health and Safety was looking for areas such as COSHH, risk analysis, training and audits. Product quality was looking for a quality system e.g. ISO 9000 with details of customer relevant sections. Continuity was looking for information on subjects such as maintenance, logistics, back-up procedures and supplier management.

#### **Question papers for module 4 – central functions**

Tuesday 5<sup>th</sup> June 1400 – 1700

Answer any FIVE questions. All questions carry the same mark of 20.

1) Your brewery has just installed a new small packaging line (canning or bottling). You have been asked to co-ordinate all the documentation that is necessary to ensure

that the plant satisfies all of the safety aspects to facilitate operation. Describe the documentation and procedures which you expect to provide.

You have also been given the responsibility to ensure that all personnel are proven competent to operate the plant safely. Describe the training plan that you would use to achieve this goal, listing any assumptions made.

2) It has been recognised that your existing compressed air system needs to be expanded by 30%. With appropriate drawings and data, describe your existing system and provide the specification for the expansion. Describe the factors which need to be considered in specifying and installing this system.

There is a need to install an air supply for a wort aeration process. Determine the main components that you would expect to see. Show the relevant pipework sizings, pressures and volumes on a schematic drawing.

3) For a brewery with keging and returnable bottling facilities, what are the factors you would consider in producing an annual calendarised budget for:

- a) engineering maintenance
- b) fuel, water and effluent.

Explain the reasoning behind the factors chosen.

The electricity supply can be regarded as a semi-variable cost. Describe how you would measure the element which could be regarded as fixed cost. Identify what measures could be taken to reduce this fixed amount.

4) There is a concern that there is a risk of contaminating beer from the secondary refrigeration system. You have been asked to conduct a risk assessment and to initiate quality and engineering procedures to eliminate the risk. Describe the procedures which you would put in place to achieve this aim, including timings and frequency.

Identify the assumptions you have made in terms of beer volume and process location of equipment in your assessment.

5) It has been reported that there is a problem with the volume and quality of condensate which is being returned to the steam boiler system. Steam is used in all areas of the brewery. You have been asked to conduct an investigation to determine the source of the problem. With reference to your own brewery and using drawings, where appropriate, describe how you would conduct this investigation.

The wort boiling system consists of a steam supplied external heat exchanger. The time to achieve boil is extended and evaporation rates are not being attained. With the aid of diagrams, describe the potential reasons for this failure and the proposed methods of rectification.

6) It has been recognised that the fermentation area is the bottleneck for production in your brewery. You have been asked to justify a capital project to increase fermentation capacity and organise the subsequent installation and introduction into operation.

Describe how you would achieve this task, making note of all assumptions made in determining the scope of the project.

7) You have been asked to devise a maintenance plan for a kegging or bottling line. The line is operating for 156 hours per week. Identify the maintenance that you would expect to conduct on the main plant items to achieve high levels of mechanical efficiency.

What maintenance and operational reporting would you expect to verify that your maintenance regime is effective?

8) It has been identified that the power factor on your electrical supply is low. You have been asked to investigate the potential cause and recommend how it should be rectified.

It has been recognised that new pumps installed on your water supply are only running at 50% of their rated load. This situation is causing problems with the pump motors. What can be done to improve the situation?

#### **Examiner's report for module 4 – central functions**

Thirty-four candidates sat the paper, with seventeen achieving a pass grade. This pass rate of 50% was slightly up on last year's performance of 48%. Only three candidates achieved a pass at grade C, while fourteen passed at grade D.

There is a lack of practical knowledge of the subjects being demonstrated in most aspects of the answers. There is a reliance on theory to address the questions. The performance on the electrically based question was extremely poor and served to emphasise that practical knowledge is a necessary prerequisite for this examination.

**Question 1** (*Your brewery has just installed a new small packaging line (canning or bottling). You have been asked to co-ordinate all the documentation that is necessary to ensure that the plant satisfies all of the safety aspects to facilitate operation. Describe the documentation and procedures which you expect to provide.*)

You have also been given the responsibility to ensure that all personnel are proven competent to operate the plant safely. Describe the training plan that you would use to achieve this goal, listing any assumptions made.

25 candidates attempted this question with 15 passing (60%).

Most of the candidates recognised the need to introduce risk assessment as a tool to determine the scope of the safety procedures for the safe operation of the line. Integration of these procedures into the Site/brewery manuals was, also, a common approach. The better candidates gave evidence of a practical analysis of the hazards, which would be present on a small packaging line, although few associated these hazards with particular equipment on the line. Few candidates included reference to the safety risk to consumers as part of their analysis, although references were made to HACCP in a general fashion.

There was a concentration on the personal safety of individuals from a procedural viewpoint. Little reference was made to the knowledge and competence of individuals in the operation of individual machines. Training plans predominantly referred to group training with a limited number of papers dealing with the

individual progress and knowledge. Few candidates identified the route that need to be taken if an individual failed to reach the required level of competency.

**Question 2** (*It has been recognised that your existing compressed air system needs to be expanded by 30%. With appropriate drawings and data, describe your existing system and provide the specification for the expansion. Describe the factors which need to be considered in specifying and installing this system.*)

There is a need to install an air supply for a wort aeration process. Determine the main components that you would expect to see. Show the relevant pipework sizings, pressures and volumes on a schematic drawing.

21 candidates attempted this question with 10 passing (48%).

The quality of the drawings associated with this question were poor with a failure of a number of candidates to recognise the correct location of component parts in the system. Few candidates were able to supplement their own system descriptions with pipework sizes or pressures. The better candidates were able to consider the size of their existing system and offer options to improve the existing performance as well as to analyse the expansion alternatives. The general performance in this section of the question, which was accountable for 30% of the marks, was very poor.

Most individuals were able to describe the main components of the system such as sterile filter, mass flowmeter, non return valve and control valve. The better answers had considered the level of dissolved oxygen in the wort to identify the mass of oxygen to be injected and were therefore able to consider pipe sizes and pressures in more detail. The injection mechanism was mentioned by only a small number of candidates.

**Question 3** (*For a brewery with kegging and returnable bottling facilities, what are the factors you would consider in producing an annual calendarised budget for: a) engineering maintenance, b) fuel, water and effluent. Explain the reasoning behind the factors chosen.*)

*The electricity supply can be regarded as a semi-variable cost. Describe how you would measure the element which could be regarded as fixed cost. Identify what measures could be taken to reduce this fixed amount.*)

14 candidates attempted this question and 5 passed (36%).

All candidates recognised that the level of production has an impact on the maintenance costs within the brewery, although a large percentage believed that the budget was totally variable with the level of production. Most candidates did not appear to recognise that the question referred to the whole brewery, including the packaging lines. There were no references to the way that the budget may be built up differently for each area of the brewery and no attempt to review individual areas to set the budget levels. There was some evidence and reference to different methods of conducting maintenance in line with predictive, preventive and breakdown, but there were few practical examples of their application and the impact on the budget.

This section was answered slightly better by most candidates with the recognition that the budget is not only influenced by the level of production, but also by the individual usage factors for each utility and the price per unit of the utility.

The concept of the fixed element of the electricity cost was understood by most of the candidates. There was little understanding from most candidates that refrigeration and electric motors were the prime contributors to a high base load. The measurement of base load and the methods to investigate its reduction were reasonably understood by the better candidates.

**Question 4** (*There is a concern that there is a risk of contaminating beer from the secondary refrigeration system. You have been asked to conduct a risk assessment and to initiate quality and engineering procedures to eliminate the risk. Describe the procedures which you would put in place to achieve this aim, including timings and frequency.*)

29 candidates attempted this question with 12 passing (41%).

The publicity which has surrounded the likelihood of this occurrence was evident in the answers received. The recommendations involving the use of tertiary systems, pressure of product exceeding the pressure of refrigerant and the alarms necessary to contain the impact of any leakage were known by the majority of candidates. There were few candidates who used volume information to determine the level of risk of contamination.

The better candidates had considered the properties of the secondary refrigerant in determining the type and frequency of the quality testing needed and consideration had also been given to the preferred type of refrigerant to be used.

Failure of plate heat the highest risk, yet no candidate considered the implications of operational procedures on the failures of these packs and reference to spare packs for replacement was also not present.

A drawing of the plant and the positioning of the pieces of equipment would have gained extra marks in consideration of the risk assessment.

**Question 5** (*It has been reported that there is a problem with the volume and quality of condensate which is being returned to the steam boiler system. Steam is used in all areas of the brewery. You have been asked to conduct an investigation to determine the source of the problem. With reference to your own brewery and using drawings, where appropriate, describe how you would conduct this investigation.*)

The wort boiling system consists of a steam supplied external heat exchanger. The time to achieve boil is extended and evaporation rates are not being attained. With the aid of diagrams, describe the potential reasons for this failure and the proposed methods of rectification.

27 candidates attempted this question with 12 passing (44%).

Very few candidates used drawings to describe the steam system in their own brewery. The resultant descriptions of fault finding were necessarily subjective and general. The better answers had attempted to identify the size and type of users of steam to determine where the

potential volume loss or contamination was occurring. There were references to both the measurement and calculation of usage to determine the expected volume of condensate being returned. The use of a team approach to determine the source of the problem was present in the better answers.

The wort boiling section was answered well in terms of heating surface contamination and its cleaning. Again, drawings with reference to the important aspects of the operation would have assisted many of the answers to be focused and considered in determining the causes of failure to achieve evaporation rate.

**Question 6** (*It has been recognised that the fermentation area is the bottleneck for production in your brewery. You have been asked to justify a capital project to increase fermentation capacity and organise the subsequent installation and introduction into operation.*)

*Describe how you would achieve this task, making note of all assumptions made in determining the scope of the project.*)

27 candidates attempted this question with 17 passing (67%).

Most candidates understood the process of managing the introduction of a capital project, but failed to utilise the project identified to expand their answer. The description in most instances could have covered any project.

The better answers had considered whether there were any alternatives which could be introduced to avoid the capital investment and had also considered the impact that the increased fermentation capacity may have on the other areas within the brewery, such as refrigeration, beer conditioning, filtration and effluent.

The integration, with the existing operations and the acceptance of the completed installation, were considered by most candidates. Few candidates made any reference to the impact on the staff except for the area of training.

**Question 7** (*You have been asked to devise a maintenance plan for a kegging or bottling line. The line is operating for 156 hours per week. Identify the maintenance that you would expect to conduct on the main plant items to achieve high levels of mechanical efficiency. What maintenance and operational reporting would you expect to verify that your maintenance regime is effective?*)

23 candidates attempted this question with 8 passing (35%).

Most candidates recognised that the line was running for all but 12 hours of every week. Some changed the length of stoppage so that longer shutdowns were accomplished for maintenance on a more infrequent basis, although in most instances the advantages of this change were not identified. Labour numbers to conduct the maintenance was rarely considered.

It was expected that a risk assessment would be conducted to determine both the criticality of the equipment and the parts which were maintainable. References were made to the types of maintenance that could be conducted but there was little practical consideration of their utilisation in a practical way.

The candidates had covered the main aspects of operational reporting which would measure the effectiveness of the maintenance regime, such as mean time between failures and mean time to repair.

**Question 8** (*It has been identified that the power factor on your electrical supply is low. You have been asked to investigate the potential cause and recommend how it should be rectified. It has been recognised that new pumps installed on your water supply are only running at 50% of their rated load. This situation is causing problems with the pump motors. What can be done to improve the situation?*)

4 candidates attempted this question and 0 passed (0%).

This question was very badly answered. There was understanding of power factor from only one candidate, and nobody was able to consider any mechanisms for its improvement, such as reduction of the brewery inductive load or installation of capacitors on the supply line.

The second part of the question was answered slightly better by one candidate with reference to improving the performance by installing a variable speed inverter. However, there had been no consideration of examining the pump application to determine the root cause of the problem nor changing of the motor to the correct type nor its impact on the site power factor.

#### **Question papers for module 5 – case study**

Wednesday 6th June 1000 – 1300

Answer ONE of the following questions.

1) The local Government, which has jurisdiction over the market in which your company produces and sells its beer, has introduced a new tax on energy. If no action is taken, like for like energy costs will increase by 20%. Describe how such an increase in energy cost would be likely to impact on the total business and how you would set about minimising its negative effect on profits.

2) Your company has produced and launched a new product onto the market in 500 ml aseptically filled bottles. The launch was successful and sales are pleasingly ahead of budget. In recent days, however, there have been a few anecdotal comments about hazy product in trade and two customer complaints have been received from approximately 500,000 bottles sold.

Assuming the bottles returned from the customers exhibited microbiological haze, describe the actions you would take in response to the situation and procedures and precautions you would put in place to assure product integrity.

Assuming the bottles returned from the customers exhibited microbiological haze, describe the actions you would take in response to the situation and procedures and precautions you would put in place to assure product integrity.

#### **Examiner's report for module 5 – case study**

This year saw a larger number of candidates attempting the paper than previous years, the total being 38. Of this group 23 (61%) passed and 15 (39%) failed, 29 chose to answer question 2 and 9 chose question 1. Whilst the pass rate was lower than last year (71%), it was pleasing to see an improvement in candidates examination technique, fewer seemed to run out of time and most read the question, though not all candidates spent enough time

planning, to ensure they covered the subject without significant repetition. Once again this year there were a few scripts of outstanding quality which were graded accordingly and my congratulations go to those candidates for their knowledge and ability.

**Question 1** (*The local Government, which has jurisdiction over the market in which your company produces and sells its beer, has introduced a new tax on energy. If no action is taken, like for like energy costs will increase by 20%. Describe how such an increase in energy cost would be likely to impact on the total business and how you would set about minimising its negative effect on profits.*)

Question 1 was not well answered, being attempted by 9 candidates of whom only 3 passed, it was evident that some candidates did not read the question or showed a worrying lack of direct experience. In an open book exam, buzz words or phrases naming energy associated items such as “combined heat and power” and “climate change levy” do not illustrate knowledge, phrases like “check for and mend compressed air leaks”, “check and replace damaged lagging”, do.

The question wanted the candidate to analyse the business for energy usage and cost reduction and how that would relate to the product and all operations. Some candidates accurately described the impact of the cost increase then considered totally inappropriate responses with investment costs which could never be justified by the benefits identified.

An ideal answer would have listed assumptions as to the size, product mix and age of plant. Proposed a structure and programme of review to allow discussion of potential short, medium and long term actions for energy usage reduction across all sectors of the business. The summary would have included fuel costs, efficiency and purchasing comments as well as recommended capital investment and appraisal systems.

**Question 2** (*Your company has produced and launched a new product onto the market in 500 ml aseptically filled bottles. The launch was successful and sales are pleasingly ahead of budget. In recent days, however, there have been a few anecdotal comments about hazy product in trade and two customer complaints have been received from approximately 500,000 bottles sold. Assuming the bottles returned from the customers exhibited microbiological haze, describe the actions you would take in response to the situation and procedures and precautions you would put in place to assure product integrity.*)

Question 2 was the preferred option, being attempted by 29 candidates of whom 20 passed therefore making it better answered than question 1. The question was looking for an objective review of the returns to justify the implementation or not of a product recall. Good answers analysed the need, impact and practical actions involved in a recall. A good candidate not only evaluated the technical justification (or not) for a product recall but also whether there was more danger to brand integrity from a small amount of defective product or the publicity of a recall. Candidates need to understand that the answer is

not always more or less of a particular action, there is also a need to analyse quality, effectiveness and timeliness of actions and systems. Use of process flow charts and HACCP charts would have been helpful as would an overview of the flow from raw material to consumer. Scripts were generally QA orientated which in itself is not wrong if the ground is covered but few candidates

managed to add practical actions and comments as to what good production practice the systems should apply.

The detail of complaints in trade infer that there is an intermittent fault on some bottles not a complete batch of beer. This focused the good candidates on packaging control, particularly the primary package and closure with indicators and overview notes on beer production.