SPECIFIC INFORMATION

Section A – Multiple-choice questions

This table indicates the approximate percentage of students choosing each distractor. The correct answer is the shaded alternative.

Question	A	B	C	D
	%			
1	3	30	56	11
2	2	89	7	2
3	69	9	15	7
4	57	11	21	11
5	35	22	21	22
6	22	10	11	57
7	85	5	9	1
8	65	6	13	16
9	6	5	30	59
10	1	8	11	80

Question	A	B	C	D
	%			
11	13	6	72	10
12	7	1	1	91
13	57	8	27	8
14	15	68	9	8
15	13	8	11	68
16	15	7	36	42
17	3	13	6	78
18	7	59	30	4
19	16	46	19	19
20	9	38	40	13

Comments on items answered correctly by fewer than 50% of the students:

Item 1

Presumably those students who chose B identified that they had found an excited state, but omitted to check that it referred to an atom, not an ion. This could have been done by checking the number of electrons and noting that, in this case, the number of electrons equalled the atomic number.

Item 5

This was the most difficult of the multiple-choice questions, while the most common response was A, choices B, C and D were all equally popular perhaps suggesting that these were random choices. It seems that very few students made the generic connection between mass and nuclear binding energy. There was a much better response to Question 5cii where the related point was much more explicit.

Item 9

The incorrect response (C), pH 7, was a strong distractor. All alpha amino acids contain both acidic and basic functional groups which will equilibrate in water to give a final pH depending on the acidic and basic strengths in the particular amino acid. In a solution of an amino acid with a pH other than 7, the amino acid would still be acting as 'both an acid and a base'.

Item 16

D was a popular but incorrect choice. The iron mesh prevents any sodium or chlorine in the liquid phase from coming together. Chloride ions will always be free to move through the mesh – indeed, they have to be able to move through the mesh so that the electric current can flow through the cell.

Item 18

Most students who chose C had obviously correctly identified the fact that 10 mole of electrons had passed through the cell; but they did not realise that the formation of every mole of chlorine requires two mole of electrons.

Item 19

It was important to realise that H_2O_2 can oxidise itself – the half reaction given shows H_2O_2 as a reductant.

Question	Marks	%	Response
Question 1	**a–f**		**1a**
	0/6	3	S
	1/6	6	**1b**
	2/6	10	Na or Mg
	3/6	15	**1c**
	4/6	23	Na
	5/6	28	**1d**
	6/6	14	anything from Ca to Ga inclusive
	(Average mark 3.89)		**1e** F **1f** Fe One mark was deducted if students used element names rather than symbols. What seemed on the surface to be an almost 'too simple' question turned out to be a great predictor for the rest of the paper.

Question 2	**a** 0/2 48 1/2 22 2/2 30 (Average mark 0.81)	An element with fewer protons (lower atomic number) can have a higher relative atomic mass if it has more neutrons in its isotopes. An essentially correct explanation scored the full 2 marks. Many students who appeared to have the general idea were unable to formulate it unambiguously, e.g. ‘because of the proton to neutron ratio tellurium has a greater number of neutrons’ – a response that is on the right track but is worth only one mark. A student giving this response may well have understood the point, but did the student mean ‘more neutrons than protons’? Or ‘more neutrons than iodine’? Students need practice in constructing clear written responses and responses need to be unambiguous.
	bi–ii 0/4 29 1/4 13 2/4 20 3/4 13 4/4 26 (Average mark 1.93)	**2bi** A transition series is formed by the progressive filling of a d subshell which has 10 electrons. **2bii** e.g. $FeCl_2$ and $FeCl_3$. No marks for ions rather than compounds. Many students suggested ions rather that molecules; others chose to combine a potentially correct molecule with the ion or molecule of another transition metal. Many students seemed to think that they had to produce something a bit unusual – whereas all that was needed was something simple, e.g. MnO and MnO_2 or $CrCl_2$ and $CrCl_3$.
Question 3	**a** 0/1 83 1/1 17 (Average mark 0.17)	$HNO_3(aq) + NH_3(aq) \rightarrow NH_4NO_3(aq)$ Surprisingly few students could find ammonium nitrate.
	b 0/1 30 1/1 70 (Average mark 0.70)	$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ Nearly all students knew about the oxidation of glucose. Most of those who were in error had messed up the stoichiometry.
	c 0/2 43 1/2 21 2/2 37 (Average mark 0.93)	One mark was given for each of: • any one of the (highlighted **CON**) were circled $NH_2CH_2COOH + NH_2CH_2COOH \rightarrow NH_2CH_2\mathbf{CON}HCH_2COOH + H_2O(l)$ • for a correct structure of the dipaptide.
	d 0/3 40 1/3 15 2/3 15 3/3 30 (Average mark 1.36)	One mark was given for each of: • the (highlighted **CHOCO** or **OCO**) were circled • for selecting the correct formula for the lipid • the correct reactants, balanced as for an equation. CH_2OH $CH_2\mathbf{OCO}C_{16}H_{33}$ | | $CHOH + 3C_{16}H_{33}COOH \rightarrow CH\mathbf{OCO}C_{16}H_{33}$ | | CH_2OH $CH_2\mathbf{OCO}C_{16}H_{33}$ Question 3c was generally well done, but 3d caused problems. While many students understood that glycerol was the correct starting point, they had difficulty in forming the three ester linkages by choosing three long chain fatty acids. In this area more practice in writing structures could help.
Question 4	**a** 0/4 9 1/4 11 2/4 22 3/4 31 4/4 27 (Average mark 2.55)	Any two of muscles, enzymes, haemoglobin, tissue repair, building of tissue and any two of lipids, protection of organs, insulation, essential fatty acids, transport of fat soluble vitamins. ***Note this question refers to the function of proteins and fats already in the human body – not to the use of proteins and fats in food.***

<table>
<tr><td></td><td>b
0/3 9
1/3 22
2/3 18
3/3 52
(Average mark 2.11)</td><td>$\Delta T = 56.8 - 21.0 = 35.8$ K

$\Delta H = 35.8 \times 4.18 \times 1000 = 149.6$ kJ

energy content = (149.6/4.75) = 31.5 kJ g^{-1}.</td></tr>
<tr><td></td><td>ci–ii
0/4 10
1/4 11
2/4 17
3/4 25
4/4 36
(Average mark 2.65)</td><td>4ci
To keep the oil and water mixed, acting as a surface active agent.
4cii
To prevent spoilage of the oil (salad dressing), by removing O_2.</td></tr>
<tr><td>Question 5</td><td>ai–ii
0/3 8
1/3 23
2/3 32
3/3 37
(Average mark 1.98)</td><td>5ai
Any one of cost, energy content, convenience of state (gas, liquid, solid), safety, emission properties.
5aii
Any two of CO, SO_2, NO_x, PAN, particulates, SO_3, O_3, H_2SO_4.</td></tr>
<tr><td></td><td>b
0/4 3
1/4 4
2/4 16
3/4 34
4/4 44
(Average mark 3.11)</td><td>For two advantages and two disadvantages from following list. (Fusion power is not acceptable for ‘nuclear’ option.)
Common advantages and disadvantages used by students in answering 5b were ‘expensive’ for a disadvantage and ‘cheap’ for an advantage. Students had to be more specific and be able to distinguish between, say, ‘running cost’ for ‘cheap’ (for say solar and wind), and, for example, ‘solar cells’ for ‘expensive’. Clearly it should not have been hard to do well on this question but many students had not apparently even thought about these issues, even though they would all be aware of the contents of the study design.
<table>
<tr><td>nuclear</td><td>• can provide major energy source
• high energy per unit mass</td><td>• radioactive waste
• earthquake danger
• terrorist danger</td></tr>
<tr><td>solar</td><td>• widely available
• no pollutant emissions
• renewable
• low running costs</td><td>• difficult to store
• not always available
• needs large catchment area
• high cost of solar cells
• low efficiency of solar cells</td></tr>
<tr><td>wind</td><td>• readily available
• no pollutant emissions
• renewable
• low running costs</td><td>• difficult to store
• unsightly
• noisy
• not always available
• needs large catchment area
• limited energy available</td></tr>
<tr><td>tidal</td><td>• no pollutant emissions
• renewable
• low running costs</td><td>• difficult to store
• limited energy available
• few useable sites available</td></tr>
<tr><td>hydro</td><td>• readily stored
• no pollutant emissions
• low running costs</td><td>• limited energy available
• unsightly
• deleterious effects on ecosystems</td></tr>
</table></td></tr>
<tr><td></td><td>ci–ii
0/2 29
1/2 37
2/2 34
(Average mark 1.05)</td><td>5ci
Atomic nucleus (or ‘atom’) is divided (either spontaneously or by collision) into two smaller nuclei (or ‘atoms’).
5cii
Any one of: nuclear (binding) energy, mass loss (i.e. $E = mc^2$).</td></tr>
</table>

Question 6	**a** 0/3 21 1/3 18 2/3 36 3/3 25 (Average mark 1.64)	Total energy needed = 13 x 800 x 10^6 = 1.04 x 10^{10} J, CH_3CH_2OH used = (1.04 x 10^{10}/1370 x 10^3) = 7591 mol, mass of ethanol = 7591 x 46 = 349 200 g = 349 kg. ***(note that the response 26.9 kg occurs if the 13 weeks is overlooked; this result was given 2 marks)***
	bi–ii 0/3 64 1/3 17 2/3 10 3/3 9 (Average mark 0.64)	**6bi** $CH_3CH_2OH(aq) + 3H_2O(l) \rightarrow 2CO_2(g) + 12H^+(aq) + 12e^-$. **6bii** Energy provided = 1.15 x (12 x 96500) = 1.33x10^6 J (1.33 MJ). ***(1 mark was awarded for correctly calculating the charge transferred but forgetting the 1.15; a mark was deducted if the significant figures in the answers to either a. or bii were further than ±1 significant figures 'out').*** Question 6b was not well answered. Most marks obtained were for working out the anode half reaction. The calculation of the energy required was the same calculation as that needed for the electrical calibration of a calorimeter but very few students were able to make the connection.
	c 0/1 37 1/1 63 (Average mark 0.63)	One of: more efficient; less pollution.
Question 7	**a** 0/2 45 1/2 23 2/2 33 (Average mark 0.87)	Electrons moving higher to lower energy levels give out specific wavelengths.
	b 0/3 41 1/3 18 2/3 21 3/3 20 (Average mark 1.2)	The dark lines are an absorption spectrum , the energy levels of H are the same as those seen in the emission spectrum except the electrons are moving up rather than down (like in AA spectroscopy). This last question of the paper was not particularly well done but it is a genuinely hard question. Questions of this nature needing simple written explanations often generate responses that are both confused and confusing. In this case, many students 'had a go' and collected a mark or two. The term 'absorption spectrum' frequently picked up a mark in an answer that had little else to recommend it. This was a most difficult question to mark because of the importance of reading each answer carefully and ensuring that each student's words were clearly interpreted and understood. This question, and similar question styles, would provide very useful examination writing practice for students.
	c 0/1 61 1/1 39 (Average mark 0.39)	$4\,^1H \rightarrow {}^4He + 2e^+$(or 2^oe_1) or $4\,^1H^+ \rightarrow {}^4He^{2+} + 2e^+$ ***(${}^2H + {}^2H \rightarrow {}^4He$ was also acceptable).*** **(No marks were deducted for omitting states on this paper.)**