2007 Senior External Examination

Chief examiner report for candidates and teachers

Chemistry

In 2007, 25 candidates sat the Chemistry examination. Paper One assessed *Knowledge of subject matter* and *Scientific processes* and was of 2 1/2 hours in length. This paper was of the usual format with 10 multiple-choice questions and eight short-response questions covering all eight syllabus topics. Part B of Paper One contained four *Scientific processes* questions assessed by applying specific criteria to each question.

Paper Two assessed *Complex reasoning processes*, with candidates being required to answer all four questions. This paper determined the levels of achievement from Sound and above. Candidates must attempt Paper Two to be considered for these levels of achievement.

The table below shows the exit levels of achievement awarded for each of the last five years.

Year	Number who sat	Level of achievement				
		VHA	HA	SA	LA	VLA
2007	25	0	5	11	7	2
2006	50	2	10	20	12	6
2005	33	2	9	9	6	7
2004	48	0	12	14	9	13
2003	74	2	14	29	16	13

The results in 2007 reflect declining Senior External Examination enrolments rather than being a result of examination difficulty or length. The comments in this report will refer to the weaknesses in candidates' knowledge and in their responses to questions. The overall results were disappointing, with no candidates achieving an overall A standard in either Part A or Part B of Paper One. The few who achieved an A standard on individual questions showed serious deficiencies in other questions, often with variable standards.

Paper One Part A — Knowledge and simple application

Multiple-choice questions

The correct response is shaded.

	Number attempted	A	B	C	D
1	25	7	15	2	1
2	25	2	1	4	18
3	25	12	1	10	2
4	24	14	8	0	2
5	25	20	1	4	0
6	25	6	1	1	17
7	25	4	4	6	11
8	25	15	4	2	4
9	25	6	12	6	1
10	25	1	18	4	2

The question topics that were poorly done were:

- Question 3 Mass of one molecule of a substance (not one mole)
- Question 4 Recognition of an oxidation-reduction reaction
- Question 7 Preparation of hydrogen in the laboratory
- Question 9 Factors affecting equilibrium position in a reaction

This represents an improved result on multiple-choice correct responses compared to 2006.

Short-response questions

This was the main part of the examination where candidates must demonstrate knowledge and understanding of the eight syllabus topics.

Question 11

Question 11(a): Few candidates gave units. Note that atomic mass units are not grams but amu.

Question 11(b): This was reasonably well done.

Questions 11(c) and (d): Few candidates mentioned noble gas configuration though the concept of the octet seemed to be generally understood.

Question 12

Questions 12(a) and (b): These were reasonably well answered, but few candidates had any success with Question 12(c). Most tried to use the gas laws.

Question 12(d): Few candidates mentioned “solute” in their definitions.

Question 13

The purposes for a salt bridge were only partly understood. The oxidation numbers of chlorine and phosphorus were reasonably well understood, but the value for mercury which is per atom was poorly determined.

Question 14

Organic chemistry seems to be difficult for many candidates. Several had difficulty expressing the meaning of saturated and unsaturated even though they seemed to understand the concepts. There was confusion between hexene, cyclohexene (as mentioned in the syllabus practical testing) and benzene in Question 14(b). Few candidates, if any, suggested preparing ethanol by fermentation despite being asked for large-scale preparation. Most suggested hydration of ethene, which received some credit.

Question 15

This question was fairly well handled, although many candidates could not name an acidic oxide in Question 14(d).

Question 16

Question 16(a): Not one candidate mentioned argon, which is 30 times more abundant than carbon dioxide. Quite a few mentioned hydrogen, and many listed ozone.

Question 16(c): No-one mentioned temperature; many listed CFCs and lightning. Some candidates said that carbon dioxide destroys the ozone layer; others merely referred to greenhouse gases.

Question 17

Questions 17(a), (c), (d) and (e): These were handled well.

Question 17(b): There was some confusion between the concept of enthalpy itself, and the enthalpy changes in a chemical reaction.

Question 17(f): Few candidates could give an example of a reaction involving negative catalysis.

Question 18

Question 18(b): No-one gained full credit.

Question 18(c): Many did not mention temperature or excess solid in the first two items respectively.

Questions 18(d) and (e): Poorly handled. Few candidates gave concentrations of acids or bases, but rather relied on the concepts of strong and weak.

Question 18(f): This was not well handled and the conjugate pairs in the equation were not fully labelled.

Paper One Part B — Scientific processes

Question 1

Question 1(a): Most candidates realised that the hydrogen chloride gas reacted with the silver nitrate, but only some could explain the reaction correctly.

Question 1(b): This was generally well handled.

Question 1(c): The usual suggestion was that too much solution would be a physical barrier to the passage of the gas. No-one mentioned the solubility of sulphur dioxide in water.

Question 2

Most candidates made some attempt at describing a titration, but there were few responses that did not have major omissions of procedure.

Question 2(c): This was very poorly answered. No-one mentioned using a primary standard, though one or two candidates mentioned weighing a solid.

Question 3

This was probably the question in Part B that was best handled, though not all candidates realised the concentration of silver nitrate is unchanged. Several candidates mentioned the impurities entering the solution but no-one distinguished more and less active metals.

Question 4

Candidates either made a reasonable attempt or had no idea. Some suggested H+ for Y+ and B (boron) for X.

Paper Two — Complex reasoning processes

Paper Two contained four questions designed to assess candidates' ability to use complex reasoning processes which broadly cover:

- problem solving in challenging and unfamiliar situations
- making logical decisions and detailed explanations
- using either creative and/or critical thinking.

Question 1 (grades awarded: 6 As, 8 Bs, 5 Cs, 6 Ds)

Question 1(a): Many candidates gave no explanation or justification for choosing magnesium. Explanation or justification is automatically required in complex reasoning questions. All responses are assessed against the criteria provided in the response book. Several candidates gave carbon as the response instead of magnesium.

Question 1(b): As many deductions as possible were required to be provided from the given data, without using other information. This included average atomic mass in addition to the particle composition, the isotopes, etc.

Question 1(c): Use of references is advised to give a more complete response, and to give ideas for constructing a good response. Candidates must note the reference/s used at the end of the page. The expected response should have contained both physical and chemical properties of magnesium, and particularly the well-known chemical reactions of magnesium. These could have been related to important concepts such as reducing power, and metal–acid reactions.

Question 2 (grades awarded: 1 A, 2 Bs, 8 Cs, 13 Ds)

Candidates did not clearly understand the identification of organic substances. It was essential, of course, that candidates worked systematically through the evidence given, and gradually narrowed the substance down to the three. The complete response is provided in the sample solutions.

Candidates are not expected to consider obscure compounds in this type of question. Many clues were given, yet they seemed to be ignored.

Some candidates confused the use of anhydrous copper sulphate as an ingredient in Fehling's solution, rather than a test for water (which it also stated!). Many made no attempt at performing calculations. This was primarily a problem-solving exercise on empirical and molecular formulae and structure.

Question 3 (grades awarded: 2 As, 9 Bs, 9 Cs, 5 Ds)

This extended-response question in the form of a scientific essay was best treated by considering each gas property one by one, using recognised definitions and then relating each to the Kinetic Theory explanations. Using examples as suggested would have supported this, and allowed for differences between various gases to be discussed.

Question 4 (grades awarded: no As, no Bs, 13 Cs, 12 Ds)

This question was challenging, and revealed grave deficiencies in candidates' understanding of the equilibrium topic. Many candidates could not distinguish between initial and equilibrium concentrations as required in the equilibrium law expression. Even the understanding of concentration as moles per litre was not considered, with many candidates using just molar masses. Some candidates assumed that 1 mol reacted, leaving 1 mol of hydrogen iodide, hydrogen, iodine, etc.

Sample solutions

The sample solutions on the following pages show possible ways of responding to the questions. They do not provide the only method of approaching a question. Other approaches and problem-solving strategies would be acceptable. These solutions have been provided as a reference to assist teachers and prospective candidates to prepare for the Senior External Examination in Chemistry.

Paper One Part A — Short response

Question 11

(a) Naturally occurring copper was found to have 70% $^{63}_{29}Cu$ and 30% $^{65}_{29}Cu$. What would be the atomic mass of this sample?

Atomic mass = 0·70 × 63 + 0·30 × 65 (1½)

= 44·1 + 19·5

= 63·6 amu

no units (−½)

value (1)

(3 marks)

(b) An atom has in its nucleus 15 protons and 16 neutrons. What would be the electron configuration of the neutral atom of this element? Explain your reasoning.

number of e^- = number of p^+ in neutral atom = 15

e.c. is $1s^2\,2s^2\,2p^6\,3s^2\,3p^3$

(−½ each error) (2 marks)

(c) Which element would you expect to have the higher first ionisation energy — sodium Na or chlorine Cl? Explain your reasoning.

Cl atom would have higher E_1

Ionisation energy increases across a row of the periodic table.

Na has one valence e^- which it readily loses (low IE) Cl tends to want to gain an e^- to complete outer shell. (2 marks)

Therefore removing an e^- (to form Cl^+) will be difficult and requires much higher energy.

(d) Explain why potassium atoms readily form K^+ ions in chemical reactions, while chlorine atoms readily form Cl^- ions.

Arrangements of electron are stable when they have the E.C. of an inert gas

$K_{19e} \longrightarrow K^+_{18e} + e^-$ ie the E.C. of Ar

$Cl_{17e} + e^- \rightarrow Cl^-_{18e}$ again the E.C. of Ar

(2 marks)

Question 12

(a) What is the mass of one mole of hydrated sodium carbonate crystals, $Na_2CO_3 . 10\ H_2O$?

$M_r = 23.0 \times 2 + 12.0 \times 1 + (16.0 \times 3) + 10 \times 18$

$= 106 + 180$

$= 286\ g$

Units $\frac{1}{2}$

$-\frac{1}{2}$ each error (2 marks)

(b) A compound was analysed and found to have the following composition by mass: carbon 23.5%; hydrogen 1.9%; fluorine 74.5%.

What is the empirical formula of this compound?

Per 100g sample

$C = \frac{23.5\ g}{12.0\ g/mol}$ (1) $\div 1.96$ mol

$H = \frac{1.9\ g}{1.0\ g/mol} \div 1.9$ mol

$F = \frac{74.5\ g}{19\ g/mol} \div 3.92$ mol

Approximating 1 : 1 : 2 (1)

$\Longrightarrow$ E.F. of CHF_2 (1)

(3 marks)

(c) Hydrogen burns in oxygen to form water vapour:

400mL 400mL

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}.$$

If a mixture of 400 mL hydrogen and 400 mL oxygen is ignited, what would be the volume of the final product **and** what would be its composition? Assume all volumes are measured at 100°C and one atmosphere pressure.

Gases molecules react in proportion to their volumes (Avogadro's Law) So 400mL H_2 consume 200mL O_2 forming 400 mL steam (not water) Leaves 200mL oxygen excess So total is 600mL, comprising 400mL steam & 200mL oxygen. (3 marks)

(d) Explain the meaning of the term "molarity of a solution".

Molarity is concentration of a solution in terms of the number of moles of SOLUTE dissolved in 1·0 litre of SOLUTION.

(2 marks)

Question 13

(a) A salt bridge is used in an electrical cell. Explain <u>two</u> purposes for the salt bridge.

(1.) completes a full circuit
(2) separates solutions
(3) prevents polarisation
More explanation might be given for full marks. 2 × 1½

(3 marks)

(b) What are the oxidation numbers for the following named atoms:

(i) chlorine in $NaClO_4$

$(+1) + Cl + (-2 \times 4) = 0$

$\therefore Cl = +7$

(ii) phosphorus in H_3PO_4

$(+1 \times 3) + P + (-2 \times 4) = 0$

$\therefore P = +5$

(iii) mercury in Hg_2Cl_2?

$2Hg + (-1 \times 2) = 0$

$2Hg = +2 \quad \therefore 1\,Hg = +1$

(3 marks)

Question 14

(a) What is meant by the terms **saturated** and **unsaturated** as applied to hydrocarbons?

A single bond only between C atoms in saturated h/cs. (Then each C atom is bonded to four other atoms). Unsatd h/cs contain at least one C=C (double bond) or C≡C (triple bond).

(2 marks)

(b) Describe the reaction of a bromine solution on cyclohexene. Include the colour change, and an equation.

Description:

Bromine red liquid decolourised by cyclohexene, an unsatd h/c

Equation: An addition reaction

or $C_6H_{10} + Br_2 \longrightarrow C_6H_{10}Br_2$ (2 marks)

(c) How can a large quantity of ethanol be prepared?

Describe the fermentation of sugars using yeast as the enzyme (catalyst) (Optional)

$C_6H_{12}O_{6(aq)} \longrightarrow 2C_2H_5OH + 2CO_{2(g)}$

(2 marks)

Question 15

(a) Name a group of elements for which the outermost energy level contains only *s* electrons.

alkali metals or Group 1

(1 mark)

(b) Name a period of elements for which the outermost energy level contains only *s* and *p* electrons.

second row of the P.T (ie Li → Ne) (or third row ie Na → Ar)

(1 mark)

(c) Name a period of elements for which the outermost energy level contains only *s*, *p* and *d* electrons.

fourth row ie $_{19}K \rightarrow {}_{36}Kr$

(1 mark)

(d) Name one example of an acidic oxide.

carbon dioxide, sulfur dioxide, nitrogen dioxide etc ONE ONLY

(1 mark)

(e) What is meant by the term **amphoteric**?

a substance behaving as an acid in one situation or a base in another situation

(1 mark)

Question 16

(a) List the major gases in the earth's atmosphere. Disregard pollutants.

nitrogen, oxygen, argon, carbon dioxide
(traces of other inert gases)
Allow water vapour.
But no pollutants. (2 marks)

(b) Explain why the presence of ozone in the upper atmosphere is important to humans.

Ozone absorbs ultra-violet radiation
(Could say $2O_3 \xrightarrow{UV} 3O_2$ in the process)
(1 mark)

(c) Explain how the amount of ozone in the atmosphere changes.

In the upper atmosphere, the amount of ozone is higher (where the temperature is colder, and so does not decompose it).
2 points, 2 marks.
(2 marks)

Question 17

(a) State the Law of Conservation of Energy.

Energy cannot be created nor destroyed, only changed from one form to another.
(1 mark)

(b) What is meant by the term **enthalpy**?

The enthalpy (or heat content) of a system is a measure of the chemical energy stored in a system. (1 mark)

(c) What is meant by the term **entropy**?

Entropy is a measure of the degree of randomness (or disorder) in a system.

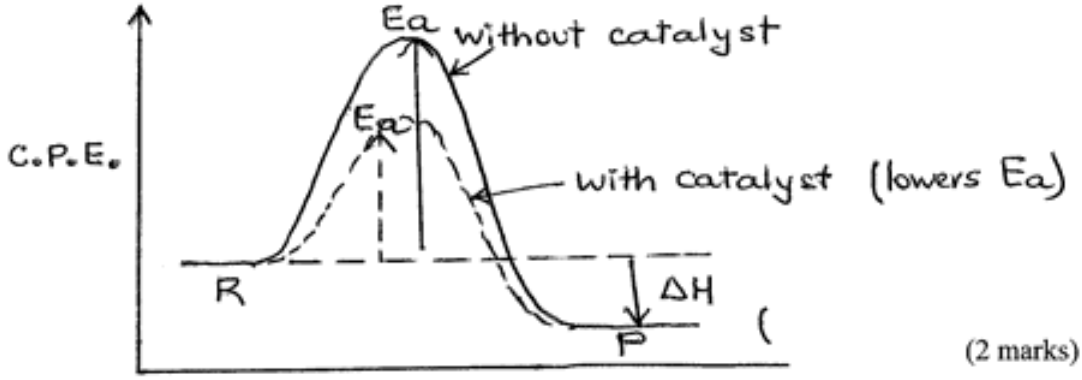
(1 mark)

(d) A reaction has a $\Delta H°$ value of -200 kJ mol^{-1}. Is the reaction exothermic or endothermic? Explain.

Exothermic ∵ −ve means heat lost in the reaction

(1 mark)

(e) Draw a labelled diagram to show how potential energy–reaction coordinate diagrams change when a catalyst is added to the reaction.



(2 marks)

(f) Give an example of a reaction where a negative catalyst (inhibitor) is used.

eg rust inhibitors
enzyme inhibitors
stabilisers

(1 mark)

Question 18

(a) What is meant by a reversible chemical reaction?

A reaction that can go back and forth between reactants and products simultaneously

(1 mark)

$$A + B \rightleftharpoons C + D$$

(b) Describe the characteristics of a reaction which has reached equilibrium.

- macroscopic properties are constant
- opposing reactions occur at equal rates
- there is a constant value of K the eq. const at a particular temp.

(2 marks) (all 3 for 2m)

(c) Give examples of the following equilibrium systems. Include states.

(i) A phase change:

$H_2O(s) \rightleftharpoons H_2O(l)$ at 0°C etc (temp needs mention)

(ii) Making a saturated solution:

$NaCl(s) \rightleftharpoons Na^+(aq) + Cl^-(aq)$ (or mention of excess solid)

(iii) A precipitation reaction:

Any suitable eg $Ag^+(aq) + Cl^-(aq) \rightleftharpoons AgCl(s)$

Note: reversible arrows (3 marks, 1 each)

(d) Name **one** of each:

(i) a strong electrolyte:

sodium hydroxide (aq) or (l) molten etc

(ii) a weak electrolyte:

acetic acid (aq) or (l) pure or NH_3 etc.

(iii) a non-electrolyte:

sugar solution

(1½ marks, ½ each)

(e) For each of the following, name one material with the given pH value.

(i) pH = 1: 0.1M HCl

(ii) pH = 3: 0.001M HCl (0.1M HAc ?)

(iii) pH = 7: pure water at 25°C

(iv) pH = 10: 0.001 M NaOH solution

(v) pH = 13: 0.1M NaOH solution

(2½ marks, ½ each)

(f) Use the Lowry-Bronsted concept of acids and bases to label the conjugate pairs in the equation

$$HNO_{2(aq)} + OH^-_{(aq)} \rightleftharpoons NO_2^-{}_{(aq)} + H_2O_{(l)}$$

$acid_1 + base_2 \rightleftharpoons base_1 + acid_2$

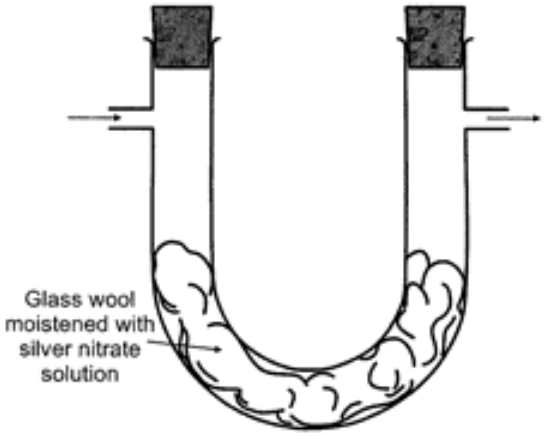
(2 marks)

Paper One Part B — Scientific processes

Short response

Question 1 — Purifying a gas mixture

A chemist has a sample of sulfur dioxide gas which contains traces of hydrogen chloride gas. In order to remove the traces of hydrogen chloride, the gases were passed through the apparatus drawn below.



Respond to the following questions:

(a) Give a scientific explanation of how the hydrogen chloride is removed.

The HCl gas DISSOLVES in the moisture
Then Cl^- precipitates with Ag^+
$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$
(The H^+ remains in moist wool along with the NO_3^- ions)

(b) The silver nitrate solution was spread over the glass wool. What is the advantage of doing this?

Higher surface area gives greater absorption of the moist HCl

(c) Why is it an advantage to use a small volume of silver nitrate solution rather than a large volume of silver nitrate solution?

Too much silver nitrate volume means too much water present which decreases the effectiveness of absorbing the HCl

ASSESSMENT CRITERIA

The candidate:

A	B	C	D	E
• responds correctly to all three sections • fully explains the reasons for the responses.	• responds correctly to all three sections but some incorrect or incomplete explanations **OR** • responds correctly to two of the three sections, **and** • fully explains reasons for the responses.	• responds correctly to one or two of the three sections • explains the reasoning with some success.	• responds correctly to one section • attempts a reasoned explanation without success.	• makes little or no attempt at the question with no success.

Question 2 — Volumetric experiment

A student was asked to determine the concentration of a quantity of hydrochloric acid solution.

In the first instance, a quantity of sodium hydroxide solution was available, and it was labelled as 0.100 M.

(a) Describe briefly the procedure whereby the student could determine the concentration of the hydrochloric acid solution using the available sodium hydroxide. Clearly list the steps in order and number them.

Doing a titration
describe in reasonable order
- the process
- terminology / apparatus (eg diag)
- at least 3 samples
- calculation as appropriate
  $N_1V_1 = N_2V_2$ or $c_1V_1 = c_2V_2$
- use of indicator
  choice of suitable

(b) What are the main possible errors that could affect the determination of the concentration?

- measuring volumes with burette & pipette
- reading volumes (parallax error)
- identifying end-point
- contaminated apparatus

(c) How could the student check that the sodium hydroxide was indeed 0.100 M as claimed?

- do pH test - would be 13.0 if 0.100M
- titrate with a primary standard which must be a suitable, pure acid (not HCl, etc) but solid acids like oxalic acid, potassium hydrogen sulfate, pot. hyd. tartrate

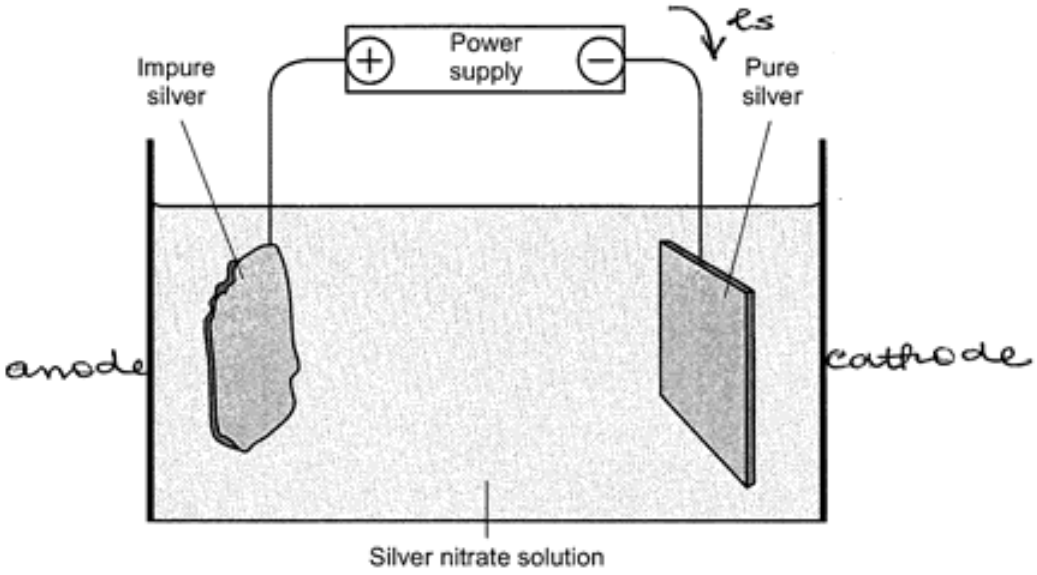
ASSESSMENT CRITERIA

The candidate:

A	B	C	D	E
• describes a suitable ordered procedure • accounts for the main possible errors • is able to give a suitable procedure to check the sodium hydroxide.	• is able to respond correctly as in A but with minor errors or omissions. **OR** • is able to respond correctly as in A for two of the three items fully.	• is able to respond to two of the three sections correctly but with minor errors or omissions.	• is able to respond to one of the three sections correctly.	• is unable to respond to any of the three sections.

Question 3 — Electrolytic refining of silver

Impure silver can be refined by the electrolytic process shown in the diagram.



Each of the following questions requires you to give a scientific explanation and to justify your response.

(a) Discuss the flow of electrons in the complete process.

(i) Where do they originate?

Electrons originate from the power supply

(ii) Where do they move to?

To the pure silver (cathode)

(iii) Where are they consumed? at the surface of the cathode

$Ag^+(aq) + e^- \rightarrow Ag(s)$ deposits on cathode

(b) Discuss the changes that take place in:

(i) the impure silver

$Ag(s) \rightarrow Ag^+(aq) + e^-$ (goes into solution)
This is oxidation

(ii) the pure silver

Reduction occurring as per $Ag^+ + e \rightarrow Ag(s)$

(iii) the silver nitrate solution.

no net change
(only migration of ions while current on)

ASSESSMENT CRITERIA

The candidate:

A	B	C	D	E
• is able to discuss the flow of electrons correctly in all three parts in (a) • is able to discuss the changes in all three parts in (b).	• is able to discuss **either** the flow of electrons **or** the changes correctly in all three parts **OR** • responds correctly in two of the three parts in (a), **and** • is able to discuss the changes in at least two of the three parts in (b).	• is able to discuss **either** the flow of electrons **or** the changes correctly in two parts **OR** • is able to discuss the changes in at least one of the three parts in (b).	• is able to discuss **either** the flow of electrons **or** the changes in only one part	• makes little or no meaningful attempt at the question.

Question 4 — Alums

Alums are double salts of the general formula

$$X_2 (SO_4)_3 . Y_2 SO_4 . 24 H_2O.$$

They have very spectacular shapes and are good examples for crystal growing. Aqueous solutions of alums contain the ions of X, Y and sulfate.

Respond to the following questions, giving a brief explanation as part of your response.

(a) Deduce the charge on each ion of X.

+3 eg Al^{3+} or Fe^{3+} or Cr^{3+}

(b) Deduce the charge on each ion of Y.

+1 eg K^+, Na^+, NH_4^+ etc.

(c) Name at least two elements that X could be.

aluminium

chromium

(ferric) iron

(d) Name at least three elements that Y could be.

sodium

potassium

lithium etc

(e) Name one polyatomic ion that Y could be.

ammonium ion NH_4^+

ASSESSMENT CRITERIA

The candidate:

A	B	C	D	E
• responds to at least four of the five sections correctly • gives brief adequate explanations.	• responds to at least three of the five sections correctly • gives brief adequate explanations.	• responds to at least two of the five sections correctly • gives brief adequate explanations.	• responds to some correctly but does not give brief adequate explanations.	• responds to sections incorrectly and does not give adequate explanations.

Paper Two

Question 1 — Identification of element by isotopic analysis

Criteria for marking Question 1: ability to solve problem correctly
ability to reason logically
ability to think critically.

For an A standard: solve the problem correctly with logical reasoning and critical thinking in all sections.

For a B standard: solve the problem correctly with logical reasoning in all sections but with no critical thinking.

For a C standard: demonstrate some attempt to solve the problem with valid explanations, but without correct solutions in two or more sections.

For a D standard: demonstrate an attempt to solve the problem, but without success and/or with invalid explanations.

Write your responses in the space below.

(a) All isotopes contain 12 protons — therefore they are isotopes of magnesium (atoms).

(b) You could list the isotopes
eg A is ^{24}Mg
You could list the full composition of each
eg. C has 12p 14n + 12e
You could find the atomic mass
ie $0.79 \times 24 + 0.10 \times 25 + 0.11 \times 26$
$= 18.96 + 2.50 + 2.86$
$= 24.32$ amu
(You could deduce group + row of the Periodic Table).

(c) any chemistry of magnesium (and its compounds eg

- properties (physical & chemical)
- combustion

$$Mg(s) + \tfrac{1}{2}O_2 \rightarrow MgO(s)$$

- reaction with acids

eg $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

- possible compounds

eg MgO $Mg(OH)_2$ $MgCl_2$ $MgSO_4$ etc

- ionisation energy $Mg(g) \rightarrow Mg^+ + 1e^-$
- $Mg(g) \rightarrow Mg^{++} + 2e^-$

etc (values quoted)

Should show reference used

Source number	Page number

Question 2 — Identifying an organic substance

Criteria for marking Question 2: ability to solve problem correctly
ability to reason logically by giving full explanation
ability to use critical thinking
ability to use creative approach.

For an A standard: solve the problem correctly in both parts of the question and demonstrate two other criteria.

For a B standard: solve the problem correctly in one part of the question and demonstrate one other criterion **or** solve the problem correctly in both parts of the question but without demonstrating two other criteria adequately.

For a C standard: demonstrate an attempt at both parts of the question and demonstrate valid reasoning but without solving the problems correctly.

For a D standard: make little progress towards solutions and demonstrate invalid reasoning.

Write your responses in the space below.

From BP of 90°C we have an organic liquid — may be a hydrocarbon or a CHO compound.

From 2, $\rightarrow CO_2$ comes from C
$\rightarrow H_2O$ comes from H
no S or N or halogens
This does not prove there is O in it.

From 3

$$C_xH_yO_z + O_2 \longrightarrow CO_2 + H_2O$$
$$15\,g \qquad\qquad 33\,g \quad 18\,g$$
$$(0.75\,mol) \quad (1\,mol)$$

$n(H_2O) = \frac{18.0}{18.0} = 1$
which contains 2.0 g H
∴ cpd contains 2.0 g H

$n(CO_2) = \frac{33.0}{44.0} = 0.75$ mol CO_2

which contains 0.75 mol C

ie 0.75×12 g C = 9.0 g

So the cpd 15g sample has

9.0g C, 2.0g H

∴ must have 4.0g O

		mol		
C	9.0	9.0/12.0	0.75	3
H	2.0	2.0/1.0	2.00	8
O	4.0	4.0/16.0	0.25	1

∴ EF is C_3H_8O

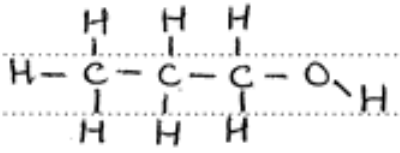
From 4, molar mass = 60g

means MF is $(C_3H_8O)_1$ ∴ EFM = 60 also

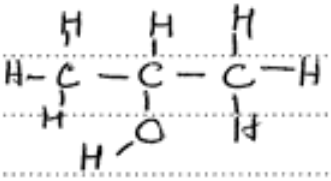
∴ SUBSTANCE C_3H_8O

Three isomers (told)

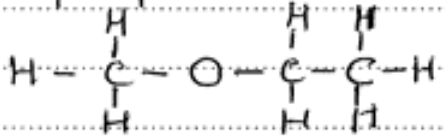
2 alcohols & 1 ether



or



propanol-1 propanol-2



an ether (ethyl methyl ether)

Other tests

(1) More BPs of each of 3

(2) Oxidising tests on p-alc, s-alc (+ ethers don't oxidise)

(3) try to form esters.

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Question 3 — Common gas properties

Criteria for marking Question 3: ability to reason logically
ability to think critically.

For an A standard: reason logically and think critically using the Kinetic Theory of gases fully for the listed properties.

For a B standard: reason logically and think critically using the Kinetic Theory of gases, but with minor errors and/or omissions for the listed properties.

For a C standard: demonstrate some attempt at the question with some valid explanations, logical reasoning and critical thinking.

For a D standard: demonstrate an attempt at the question but with limited success, and/or with invalid explanations and not critically examined.

Write your responses in the space below.

Explain each term
Relate each to Kinetic Theory
Give some examples of differences between gases, using the above.

1. Pressure
   - molecular motions
   - collisions with wall of container
   - more particles → more collisions → higher pressure
   - higher temperature → particles move faster → more energetic collisions → higher pressure

   EXAMPLE Total pressure of air
   Subpressures of N_2 O_2 etc (partial pressures)

2. Diffusion – gases diffuse rapidly
   eg. through room or if a leak
   At given temp, have same average KE, but because masses differ their average speeds are different

EXAMPLE diffusion rates for H_2 (the lightest gas v. say Cl_2 or Br_2 etc.

3. Compressibility – compression reduces space between molecules / particles
   - depending on shape & bonding types some pack better & attract one another better

EXAMPLE H-bonding in water.
Why does steam condense fairly easily?
Why is BP of He, H_2 so low?

4. Solubility of gases in water - very varied
   - gases with higher solubility often dissolve in water and also react with water (an equilibrium situation)

eg $NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$

$CO_2 + H_2O \rightleftharpoons H_2CO_{3(aq)}$

   - but gases which have low solubility in water, tend not to react

eg N_2 O_2 etc

   - The higher the temperature, the lower the solubility – faster moving – easier escape from surface of water.

Probable use of references →

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Question 4 — An equilibrium system

Criteria for marking Question 4: ability to solve problem correctly
ability to reason logically
ability to be critical
ability to be creative.

For an A standard: solve the problem correctly with logical reasoning and critical thinking.

For a B standard: solve the problem correctly with logical reasoning but no critical thinking.

For a C standard: demonstrate some attempt to solve the problem with valid explanations, but without correct solution.

For a D standard: demonstrate little or no attempt to solve the problem, without success and/or with invalid explanations.

Write your responses in the space below.

$H_{2(g)} + F_{2(g)} \overset{1L}{\rightleftharpoons} 2HF_{(g)}$

$K = 1.0 \times 10^2 = 100$

(ie equil very much to the RIGHT)

Initial mole	2·0	2·0	NIL
Reacts	$-x$	$-x$	$\rightarrow 2x$
at equil moles	$(2-x)$	$(2-x)$	$2x$
Concn eq	$\frac{2-x}{1}$ M	$\frac{2-x}{1}$	$\frac{2x}{1}$ Molar

But $K = \dfrac{[HF]^2_{EQ}}{[H_2]_{EQ}[F_2]_{EQ}}$

$100 = \dfrac{(2x)^2}{(2-x)(2-x)}$

$100(2-x)^2 = 4x^2$

$100(4 - 4x + x^2) = 4x^2$

$25(4 - 4x + x^2) = x^2$

$100 - 100x + 25x^2 = x^2$

$24x^2 - 100x + 100 = 0$

$6x^2 - 25x + 25 = 0$

$(2x - 5)(3x - 5) = 0$

$x = 2.5$ or $1\frac{2}{3}$ (ie 1.67)

The first is not possible chemically

So only consider $x = 1.67$

at equil, conc H_2 = 0.33 M

conc F_2 = 0.33 M

conc HI = $2x = 2 \times 1.67$

= 3.34 M

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