Scots Trial Paper Chemistry 2004

Solutions, syllabus outcomes and marking criteria

PART A: Questions 1-15

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answer	A	C	B	C	A	D	D	C	D	D	A	A	B	D	D
Outcomes	H9	H9	H10 H12	H6, H7, H8	H6	H8, H10	H8, H10	H8, H10	H6	H11, H12	H9	H10, H14	H11	H11	H10, H14

1 **Correct Answer A**
Chloroethene (with the double bond)

2 **Correct Answer C**
The other molecules apart from cellulose are produced from addition polymerisation.

3 **Correct Answer B**
$n(C_2H_5OH) = m/M$
$= 11.5g/46.07g\ mol^{-1}$
$= 0.249\ mol$

Heat of combustion $= 0.249\ mol \times 1360\ kJ/mol$
$= 339.48$
$\approx 340\ kJ$

4 **Correct Answer C**
A gives 1.6V, B gives 0.52V, C gives 1.98V, D gives 1.04V using the table of standard reduction potentials.

5 **Correct Answer A**
Transuranic elements have an atomic number greater than 92.

6 **Correct Answer D**
Acid strength is measured by the extent of ionisation of the acid. Weak acids ionise less than stronger acids.

7 **Correct Answer D**
Since both acids have the same pH, their respective [H+] must be the same. However, acid A is of a lower concentration and so must be a stronger acid.

8 **Correct Answer C**
An increase in [H+] will result in a lower pH. The hydrogen sulfate ion, derived from a polyprotic acid will undergo a hydrolysis reaction to form a more acidic solution.

9 **Correct Answer D**

10 **Correct Answer D**
The solution to be delivered is used as the final rinse to avoid dilution.

11 **Correct Answer A**
Each monomer has two functional groups.

12 **Correct Answer A**

The formation of ammonia is exothermic, and so its yield will increase at lower temperatures. According to Le Chatelier's Principle, in this case the equilibrium will shift to the right as pressure is increased.

13 **Correct Answer B**

14 **Correct Answer D**

15 **Correct Answer D**

The equation for the reaction is A + B □ 2C. Since one mole of each A and B are consumed to form 2 moles of C, there are 2 moles of gas on each side of the equation. Therefore the ratio of moles is unaffected by the change in pressure.

Part B : Questions 16-26

Question 16 (7 marks)

Q.16 (a)

Outcomes assessed: H	Marks
• Correctly states the difference between the reactivity of alkanes and alkenes AND • Gives a valid reason	2
• Correctly states the difference between the reactivity of alkanes and alkenes	1

Specimen answer

Alkenes are more reactive than alkanes because the double bond in alkenes is more amenable to chemical (electrophilic) attack than the single bond in alkanes.

Q.16 (b)

Outcomes assessed: H	Marks
• Correctly names an alkane and an alkene **available in the school science laboratory** AND • Describes a valid distinguishing test including the reagents, their amounts and equipment needed AND • Correctly states the outcome of the test AND • Write a correct chemical equation (with states) for the effect of the test on the **named** alkene	4
• Correctly names an alkane and an alkene **available in the school science laboratory** AND • Describes a valid distinguishing test including the reagents, their amounts and equipment needed AND • Correctly states the outcome of the test OR • Write a correct chemical equation (with states) for the effect of the test *any* alkene	3
• Correctly names an alkane and an alkene **available in the school science laboratory** AND • Describes a valid distinguishing test **without** including equipment needed OR • Correctly states the outcome of the test OR • Write a correct chemical equation (with states) for the effect of the test on *any* alkene	2
• Correctly describes ***some*** aspect of a suitable distinguishing test for alkenes and alkanes **OR** • Write a correct chemical equation (with states) for the effect of the test on *any* alkene	1

Specimen answer

Cyclohexane and cyclohexene can be distinguished from one another by shaking a 1 mL sample of each in separate test tubes with a few drops of bromine water. The cyclohexene will *decolourise* the bromine water the cyclohexane will not.

$C_6H_{10}(l) \xrightarrow{Br_2(aq)} C_6H_8Br_2(l)$

OR

$C_6H_{10}(l) + 2Br_2(aq) \rightarrow C_6H_8Br_2(l) + 2HBr(aq)$

OR some other valid reaction

Question 17 (5 marks)

Q.17 (a)

Outcomes assessed: H	Marks
• Names a specific biopolymer AND • Identifies the specific enzyme or organism used in its synthesis AND • Identifies its physical and/or chemical properties AND • Identifies its uses or potential uses AND • Evaluates the production of these plastics in terms of cost and possibility of cost effectiveness in developments in genetic technology	5
• Names a specific biopolymer AND • Suggests uses, properties OR its physical and/or chemical properties AND • States the advantage of biodegradability of such a plastic OR • Evaluates the production of these plastics in terms of cost and possibility of cost effectiveness in developments in genetic technology	3 - 4
• Names a specific biopolymer AND/OR • Identifies the specific enzyme or organism used in its synthesis OR • Evaluates the production of these plastics in terms of cost and possibility of cost effectiveness in developments in genetic technology	1 - 2

Specimen answer

Biopolymer:

PHB – polybetahydroxybutanoate

Synthesis details

- Produced by some of the following organisms – Alcaligenes, Clostridium,
- Polymer has similar physical and mechanical properties to polypropylene but different chemical structure.

Uses

- PHB can be used in the production of packaging, e.g. bags, wrapping film etc. The main advantage over polypropylene is that it is biodegradable thus these plastics would rapidly degrade in landfills.

Evaluation

- However the cost of production of these plastics is very much higher than for plastics from petrochemicals.
- Improvements in genetic technology may assist in the future production of these plastics making it more economically viable.

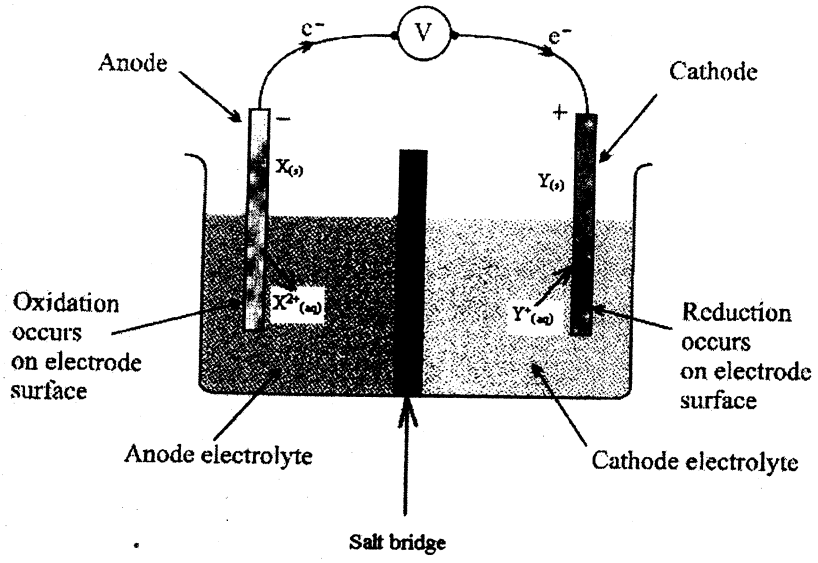
Question 18 (6 marks)

Q.18 (a)

Outcomes assessed: H	Marks
• Correct diagram (including anode, cathode, salt bridge) showing correct directions of electron AND ion movements	3
• Correct diagram (including anode, cathode, salt bridge) showing correct direction of electron movement	2
• Correct diagram (including anode, cathode, salt bridge) but no electron or ion movement OR correct direction of electron or ion movement	1

Specimen answer

Diagram:



Q.18 (b)

Outcomes assessed: H	Marks
• Correct half equation AND voltage	2
• Correct half-equation OR • Correct voltage	1

Specimen answer

Cell voltage:

$$E^{\ominus}_{cell} = E^{\ominus}_{ox} + E^{\ominus}_{red}$$

$$0.96 = E^{\ominus}_{ox} + 0.52 \text{ V}$$

$$E^{\ominus}_{ox} = 0.44 \text{ V}$$

Oxidation half-equation:

$$X_{(s)} \rightleftharpoons X^{2+}_{(aq)} + 2e^{-}, \quad E^{\ominus}_{ox} = +0.44 \text{ V}$$

Q.18 (c)

Outcomes assessed: H	Marks
• Predicts effect on cell voltage *based on Le Chatelier's principle*	1

Specimen answer

By Le Chatelier's principle, if the concentration of a reactant is increased the equilibrium will be driven to the right, producing a higher concentration of products until a new equilibrium is reached.

Hence, once more Y^{+} is available for reduction, the system will respond by producing more $Y_{(s)}$, so the cell voltage will increase once more until the new equilibrium is established.

$$X_{(s)} + 2Y^{+} \rightleftharpoons 2Y_{(s)} + X^{2+}_{(aq)}$$

Question 19 (3 marks)

Q.19

Outcomes assessed: H	Marks
• Names a radioisotope used in medicine or in industry • States it nuclear properties (type of radiation emitted and half life) • Relates its chemical and/or nuclear properties to its medical (or industrial) use	3
• As above but missing any one item	2
• As above but missing any two items	1

Specimen answer

Medical Radioisotope: Iodine-131

Uses

- Used as a **radioactive tracer** to **diagnose** thyroid problems and also to treat cancer of the thyroid (**radiotherapy**).
- It is injected into the blood where it concentrates in the thyroid, particularly where abnormal growth is taking place

Nuclear and chemical properties and how these relate to its uses

- **I-131** is a **gamma emitter** with a **half-life of 8 days**
- The isotope decays as shown in the following equation:

$$^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\mathrm{e} + \gamma + \bar{\nu}$$

- The γ-radiation from the decay of the isotope **can easily penetrate a patient's body** and be picked up by detectors. It also interferes with the division of cancer cells and kills them.
- The short 8 day half-life means that it **does not remain for long in the patient** to cause long term damage to other tissues.
- The half life is **long enough, however to be delivered to the hospital** from the Lucas Heights reactor where it is produced.
- Research is under way into how to deliver such isotopes more precisely to the sites of cancer

OR...

Industrial Radioisotope: Americium-141

Uses

- Americium-241 is used in industry for quality control (eg. measuring thickness of metal sheet produced by steel mills) and in smoke detectors

Nuclear and chemical properties and how these relate to its uses

- Americium-141 is an alpha and gamma emitter and has a half-life of 432 years

$$^{241}_{95}\mathrm{Am} \rightarrow {}^{237}_{93}\mathrm{Np} + {}^{4}_{2}\alpha + \gamma$$

- The gamma radiation is used to accurately measure the thickness of such things as steel and plastic because the amount of radiation that penetrates a material depends on its thickness.
- The alpha radiation of **Am-241** is used in smoke detectors to ionise the air between two parallel plates and the flow of ions (current) between the plates. This current is constantly monitored. If there is smoke in the air, smoke particles are attracted to ions in the air, making them heavier. This changes the flow of ions between the plates, which in turn sets off the alarm

Question 20 (5 marks)

Q.20 (a)

Outcomes assessed: H	Marks
• Calculation of the correct **average** titre with readings 1 and 4 excluded WITH • **justification** of why the average was used and why readings 1 and 4 should be excluded AND • Correct **calculation** of sodium carbonate concentration	3
• Calculation *without justification* of an **average** titre (with or without readings 1 and 4) AND • *Correct* calculation of sodium carbonate concentration	2
• Correct *balanced* equation. OR • Some correct working	1

Specimen answer

Run	1	2	3	4	5
Initial burette volume (mL)	0.5	23.6	0.7	23.5	0.2
Final burette volume (mL)	23.5	45.8	23.0	46.2	22.4
Volume used	23.0	22.2	22.3	22.7	22.2

Steps in the calculation of the $[Na_2CO_3]$ with justification

- The **average** titre will be calculated to make best use of the data collected.
- However, the first (rough) titre value and the fourth titre value will be **excluded** as they are too far away from the other readings; i.e., readings 2, 3 and 5 are all within 0.1 mL of each other which is within the **precision of the burette** Therefore, the average volume of the *concordant* readings is 22.23mL ≈ 22.2 mL.
- In the calculation of the $[Na_2CO_3]$ the 22.23mL value will be used and the final answer will be rounded off.

Calculation of $[Na_2CO_3]$

$$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

$$\frac{n_{Na_2CO_3}}{n_{HCl}} = \frac{(cV)_{Na_2CO_3}}{(cV)_{HC}}$$

$$\frac{1}{2} = \frac{c_{Na_2CO_3} \times 25.0\ mL}{0.0246\ mol\ L^{-1} \times 22.23\ mL}$$

$$c_{Na_2CO_3} = \frac{1}{2} \times 0.0246\ mol\ L^{-1} \times \frac{22.23\ mL}{25.0\ mL}$$

$$c_{Na_2CO_3} = 0.109\ mol\ L^{-1}$$

Q.20 (b)

Outcomes assessed: H10, H12	Marks
• Chooses correct indicator and provides appropriate reason	2
• Chooses correct indicator	1

Specimen answer

Reaction between a strong acid and a weak base will produce a weakly *acidic* solution, so of the two indicators provided, methyl orange should be chosen as its endpoint is acidic region – although perhaps, it is still a little too low to pick up the equivalence point.

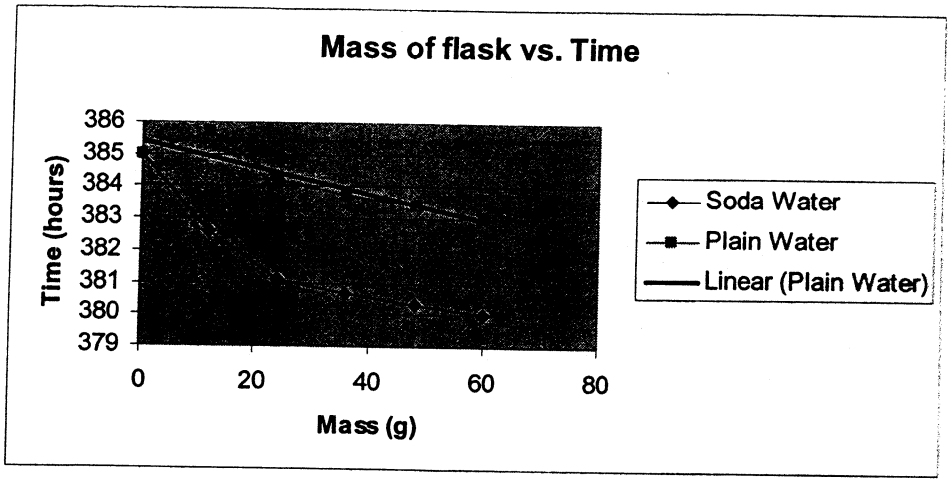
Question 21 *(7 marks)*

Q.21 (a)

Outcomes assessed: H	Marks
• Correctly plots points (axes must be labelled and suitable of scales must be used) AND • draws sound lines of fit for both data sets	2
• Correctly plots points but draws incorrect lines OR plots *one* set of data correctly OR • Plots points for both sets of data correctly without drawing trendlines…	1

Specimen answer

Graph



Q.21 (b)

Outcomes assessed: H	Marks
Interprets the graphs to: • identify the trend in the water graph to be due to evaporation alone AND • identify the trend in the soda water graph to be due to both evaporation **and** CO_2 loss • identify that the trends become virtually identical once most of the dissolved CO_2 gas gone	3
• Identifies two of these trends	2
• Identifies any one trend	1

Specimen answer

- Both graphs show a decrease in mass over time.
  - The water graph shows the loss of mass due to **evaporation alone**.
  - The soda water graph shows the loss of mass due to water evaporation **AND** loss of carbon dioxide gas.
- When no more CO_2 remains the soda water graph parallels the water graph as evaporation continues.

Q.21 (c)

Outcomes assessed: H	Marks
• Correct calculation using mass of carbon dioxide from graph AND • Correct value and formula for molar volume of gas evolved	2
• Correct formula for molar volume of gas but incorrect value from own graphs OR • Correct value from graph used, but incorrect formula for molar volume of gas	1

Specimen answer

From the water graph, the water loss (by both samples) due to ***evaporation*** = 2 g.
The total mass loss of the soda water sample = 5 g. So the ***mass of CO_2 lost*** = 3 g.
Volume of CO_2 gas lost = No. moles x molar volume at 25°C:

$$V_{CO_2} = \frac{3.0\ g}{44\ g\ mol^{-1}} \times 24.79\ L\ mol^{-1} = 1.69\ L$$

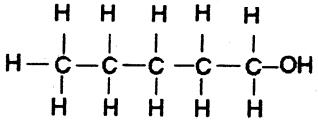
Question 22 *(8 marks)*

Q.22 (a)

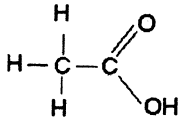
Outcomes assessed: H11, H9, H8	Marks
• Correctly draws the structures of *both* reactants AND • Correctly names (IUPAC) *both* reactants	3
• Correctly draws the structures of *one* reactant AND • Correctly names (IUPAC) *both* reactants **OR** • Correctly draws the structures of *both* reactant AND • Correctly names (IUPAC) *one* reactants	2
• Correctly draws the structure of AND correctly names *one* of the reactants	1

Specimen answer

1-Pentanol



Ethanoic acid

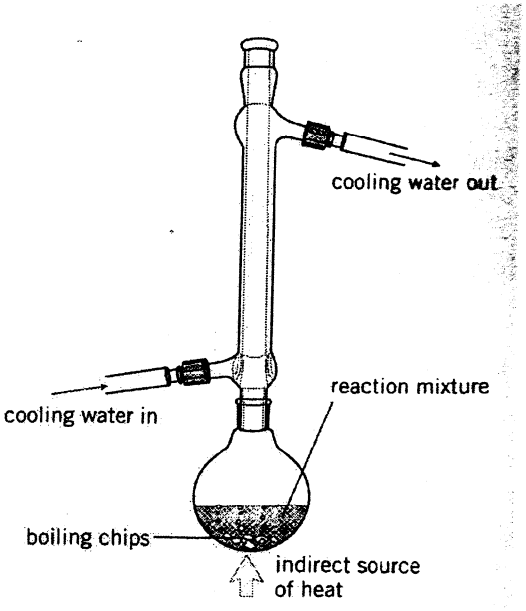


Q.22 (b)

Outcomes assessed: H11, H9, H8	Marks
• Correctly *draws* and *labels* he apparatus required for the production of an ester in the school laboratory including: *(2 marks)* – Round bottom flask (with boiling chips *optional*) – Reflux condenser – Heat source (heating mantle, oil bath, Bunsen [less desirable]; *not water bath*) – Water inlet and outlet (with correct water flow direction labelled) AND • Draws items correctly – 2 dimensional, correct relative sizes…*(1 mark)*	3
• As above, with one or more of the above not included	1-2

-1 mark for each missing/incorrect item

Specimen answer



Q.22 (c)

over page.../p	Marks

Q.22 (d)

over page.../p	Marks

Q.22 (c)

Outcomes assessed: H	Marks
• Correctly identifies concentrated sulfuric acid acting as a catalyst (do no *not* allow 'acting as a dehydrating agent')	1

Specimen answer

Sulfuric acid serves as a **catalyst**

Q.22 (d)

Outcomes assessed: H	Marks
• Correctly explains the need for refluxing	1

Specimen answer

Refluxing allows the reactants to remains in contact at high temperature for an extended time without building up the pressure (as would occur in a sealed flask).
It is also a safety precaution as it prevents the escape of inflammable vapours.

Question 23 *(5 marks)*

Q.23 (a)

Outcomes assessed: H	Marks
• Correctly identifies *any one* three precipitates *or* the gas (the letter identifying the substance ***must*** be quoted) • Writes the correct net ionic equation the formation of the species identified (must include states and correct balancing numbers) (2 marks) • Identifies the anions present in the original solution.	4
• Deduct one mark for each mistake/omission	1-3

Specimen answer

Species *(1 mark)*	**Net ionic equation *(2 marks)***
Precipitate H: Zinc carbonate:	$CO_3^{2-}(aq) + Zn^{2+}(aq) \rightarrow ZnCO_3(s)$
Precipitate J: Barium sulfate:	$SO_4^{2-}(aq) + Ba^{2+}(aq) \rightarrow BaSO_4(s)$
Precipitate K: Lead iodide :	$2I^-(aq) + Pb^{2+}(aq) \rightarrow PbI_2(s)$
Gas L: Carbon dioxide:	$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_3(g)$

Anions present in original solution: CO_3^{2-}, SO_4^{2-} and I^- (symbols or names, ***1 mark***)

Q.23 (b)

Outcomes assessed: H	Marks
• Correctly describes a test that would distinguish the two ions	1

Specimen answer

Test for Ba^{2+} ions: Add a few drops of dilute $H_2SO_4(aq)$ to about a mL of solution in a test tube. The formation of a white precipitate indicates the presence of $BaSO_4$. $MgSO_4$ is soluble.

Question 24 *(6 marks)*

Q.24 (a)

Outcomes assessed: H	Marks
• Outlines a valid procedure. A minimum answer must include accurate weighing, addition of a precipitating agent, filtering, drying and weighing. AND • Describes the chemistry underlying at least *two* of the steps	3
• Outlines a valid procedure. A minimum answer must include accurate weighing, addition of a precipitating agent, filtering, drying and weighing. AND • Describes the chemistry underlying *one* of the steps	2
• Outlines a valid procedure. A minimum answer must include accurate weighing, addition of a precipitating agent, filtering, drying and weighing but fails to describe any of the chemistry involved.	1

Specimen answer

Procedure and chemistry

	Procedure	Underlying chemistry
1	**Accurately weigh** a sample of the fertiliser. **Dissolve** it in 25 mL of distilled water	
2	**Acidify** the solution with 1 mL of conc HCl and dilute to 200 mL. **Heat** gently on a hotplate	**Heating** removes any NO_3^- present as $HNO_3(g)$ and prevents co-precipitation of $Ba(NO_3)_2$. **Acidic conditions** help form an easily filterable precipitate and reduces co-precipitation*
3	**Slowly** add **hot** dilute $BaCl_2$ solution to the ***hot* solution** with thorough stirring * ***In acid solution***, negatively charged SO^{2-} ions are ***primarily* adsorbed** (since a precipitate tends to adsorb it own ions) and some positively charged H^+ *counter ions* (supplied by the acid) are ***secondarily* adsorbed**. The H^+ counter ions neutralise the negative primary layer and allow the particles to coagulate to form the precipitate.	*Barium ions* cause the sulfate to precipitate as insoluble $BaSO_4$ $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ Carrying our the precipitation *at elevated temperature* reduces supersaturation which results in the formation of small crystals Carrying out the precipitation in *dilute* solution and the *slow* addition of the $BaCl_2$ precipitating reagent with *thorough stirring* also favours the *growth of large easily filterable* $BaSO_4(s)$ *crystals and reduces the* co-precipitation of $BaCl_2(s)$ onto them
4	**Cover the solution** containing the precipitate with a watch glass and **Allow it to stand** for 12-24 hours at room temperature.	This is a *digestion* phase: it allows the *precipitate crystals to grow large* which makes them *more readily filterable* and *reduces the amount of contamination by co-precipitation* The volume of solution should not fall below 150 mL *to prevent supersaturation* (which reduces crystal size)
5	**Filter** off the precipitate using a **sintered silica funnel.**	A sintered glass funnel is used instead of filter paper to prevent the reduction of the hot sulfate to sulfide by the carbon in filter paper: $BaSO_4(s) + 4C(s) \rightarrow BaS(s) + 4CO(g)$
6	**Wash** with several small aliquots of hot water	The *small* wash portions remove impurities more efficiently than one larger wash portion *Hot* washings increase the solubility of impurities and increase the speed of filtration *Water* is suitable because $BaSO_4$ is very insoluble in water (3 mg/L at room temperature)
7	**Dry** in a desiccator and **weigh**. Repeat until a constant mass is obtained	Desiccator prevents water from the atmosphere adhering to the crystals

Question 24 *(continued)*

Q.24 (b)

Outcomes assessed: H	Marks
• Summarises the results obtained and assesses their reliability AND • Identifies at least one problem AND • Suggests a feasible procedure that possibly alleviate it.	3
• Summarises the results obtained and assesses their reliability AND • Identifies at least one problem OR • Identifies at least one problem AND • Suggests a feasible procedure that possibly alleviate it.	2
• Summarises the results obtained and assesses their reliability OR • Identifies at least one problem	1

Specimen answer

Assessment of reliability

The results were *not very reliable* because the mass of sulfate obtained was much higher than that expected from the assay on the packet. This was not due to the fact that the determination was carried out only once since all groups in the class obtained similar results.

Problems and solutions

	Problem	Possible Solution
1	Some precipitate passed through the sintered glass funnel	Allow a greater digestion time. Digest at a warm temperature to prevent supersaturation which causes the formation of small crystals.
2	The final precipitate was too heavy	If this was due to coprecipitation of impurities, the $BaCl_2$ precipitating agent should be added more slowly and more washing may be needed after filtration. If this was due to incomplete drying, ignition of the precipitate may be required.

Question 25 *(6 marks)*

Q.25 (a)

Outcomes assessed: H	Marks
Reaction of CFC with ozone	

Specimen answer

Either freon–11 or CFC-11 or trichlorofluoromethane used in **plastics** OR
Freon-12 or CFC-12 or dichlorofluoromethane used in **refrigeration** or **air-conditioning** OR
Freon-13 or CFC-13 or 1,1,2-trochloro-1,2,2-trifluoromethane used as a **solvent**

Q.25 (b)

Outcomes assessed: H	Marks
• Shows the breakdown of a CFC molecule to form a chlorine atom or ClO AND • Shows this free radical attacking the ozone to break it down into O_2	2
• Shows any one equation correctly	1

Specimen answer

Reaction of CFC with ozone

CCl_3F + *ultraviolet light* → Cl + CCl_2F

CCl_2F_2 + *ultraviolet light* → Cl + $CClF_2$

Cl + O_3 → ClO + O_2

ClO + O → O_2 + Cl

Q.25 (c)

Outcomes assessed: H	Marks
• Clearly explains the bonding in the replacement molecule, how it functions including the cost and its efficiency	3
• Suggests the name of the molecule and bonding OR • How the molecule functions including the cost or its efficiency	2
• Suggest the name of the molecule only and how it functions	1

Specimen answer

HFCs (hydrofluorocarbons) are now widely used as replacements for CFCs.
HFCs are compounds containing hydrogen, fluorine and carbon, but no chlorine. They contain C-H bonds and so undergo some decomposition in the troposphere,
They contain no C-Cl bonds so do not form Cl atoms in the stratosphere so their ozone destroying capacity is zero.
HFC-134a, 1,1,1,2-tetrafluoroethane is now widely used in refrigeration and air-conditioning in Australia. It is more expensive than the CFCs it replaces and somewhat less efficient.

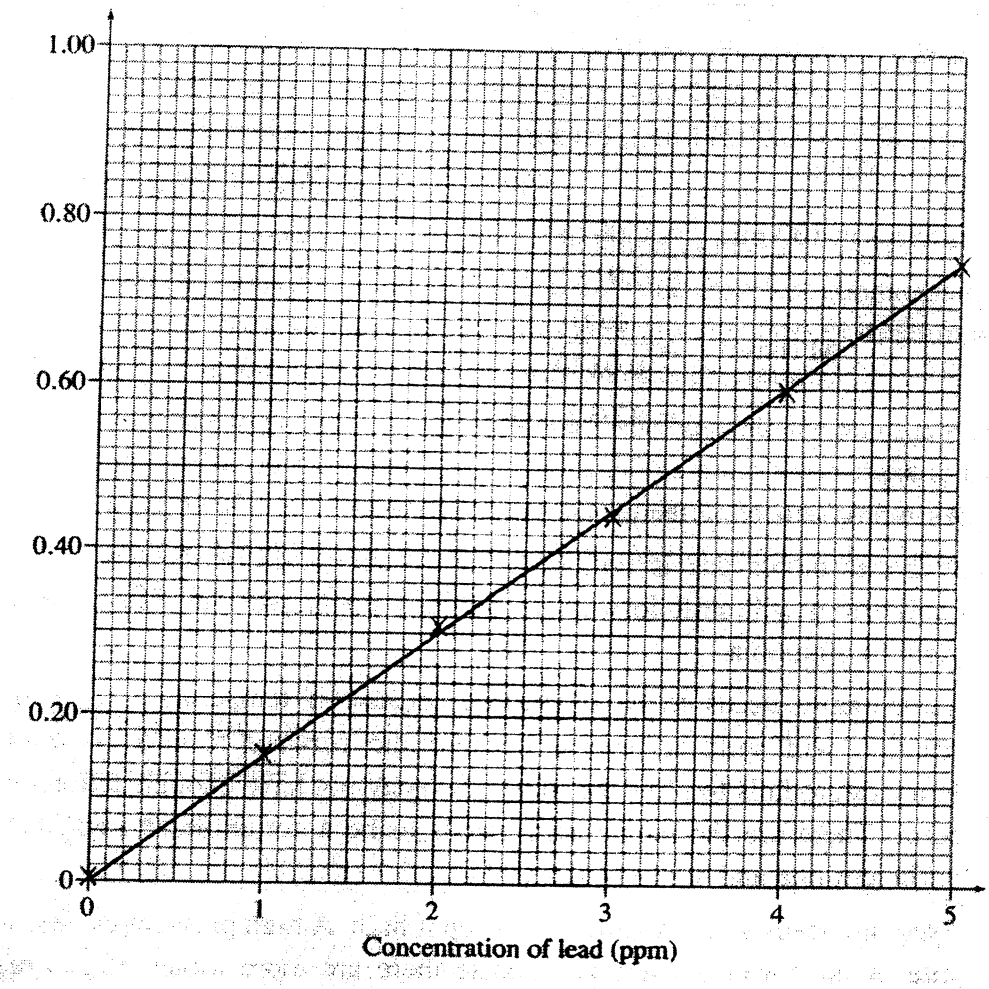
Question 26 *(3 marks)*

Q.26 (a)

Outcomes assessed: H	Marks
• Correctly plotted graph	2
• One point incorrectly plotted or line of fit not drawn correctly	1

Specimen answer

Graph:



Q.26 (b)

Outcomes assessed: H	Marks
• Correct value from own graph	1

Specimen answer

Lead concentration when absorbance is 0.19 = 1.3 ppm (using graph)