CHEMISTRY (CHM 415115)

FEEDBACK FOR STUDENTS AND TEACHERS

PART 1

CRITERION 5

GENERAL COMMENTS

A common problem throughout this entire section was failure to recognise that metal ions are generally oxidisers and that metals are reducers. Metals are not oxidisers. Also, students often neglected to use chemical equations to support their answers.

QUESTION 1

- Generally well done.
- Students should balance half-equations using the whole species (MnO₄⁻) rather than just the metal ions (Mn²⁺).
- Balancing of electrons appeared to cause difficulty for many.
- Students needed to cancel out electrons, hydrogen ions and water in their overall equation to gain full marks.

QUESTION 2

a) Marks awarded for answering question (yes) (½), explaining redox as a transfer of electrons (½), showing the change of oxidation states or half-equations for all species (1).

b) Students found this question very difficult. Students needed to consider the oxidation state of copper in the hexafluorocuprate ion before assigning it an oxidant.

QUESTION 3

a) Students found this part of the question surprisingly difficult.
   - Students regularly missed the point of this question.
   - The concentration of the hydrochloric acid was important with regards to the chloride ions, not the hydrogen ion.
A number of students incorrectly thought chlorine gas was reacting with manganese dioxide.

- Students needed to discuss relative reducing strength compared to water.
- For full marks, students needed to discuss the dilute and concentrated hydrochloric acid cases.

b) Students need to be careful talking about oxidisers versus reducers here.

- Lithium ions are weak oxidisers, lithium metal is a strong reducer.
- To gain full marks students needed to consider the competition of water and lithium ions in terms of oxidising strength AND that lithium metal is highly reactive with water, plus mention how this relates to the operation of a lithium battery.

QUESTION 4

a) Generally well done.

- Marks were awarded for zinc is a stronger reducer (1), it is a sacrificial anode (1) and the two relevant half equations (1).
- Many students did not include the relevant equations.
- Many students referred to steel and not iron.
- Students confused galvanising with the zinc paint.

b) Quite poorly done considering the standard nature of the question.

- Marks awarded for diagram that included clear reference to anode and cathode (1) a written description of why oxidation occurs (1) and the two relevant half equations (1).
- Both differential aeration (due to water collecting in the hole), or disruption to the metallic lattice were accepted as explanations of where the anode site formed.
- Students’ diagrams were generally misguided, labelling included “pole” and “hole” which was not sufficient to be awarded marks.
- Many students did not mention the redox chemistry involved in corrosion, rather giving year 8 level detail.
QUESTION 5

Generally poorly answered.

a) For full marks the powerpack itself should be labelled clearly (not the electrodes and avoid using just the battery symbol only).

b) Four half equations presented in the correct order of oxidation preference were expected for full marks.
   - These were for the oxidation of zinc, nickel, copper and water.
   - Mentioning that gold was not oxidised was also accepted.
   - Many students did not include all the possible oxidation half equations, or included the oxidation of gold to gold ions (note that this will not occur in aqueous electrolysis).

c) Students should take care with the use of terminology - nickel and zinc ions are oxidisers, not nickel and zinc metal.
   - The copper sulfate electrolyte provides the copper ions that are preferentially reduced in the electrefining process.
   - Anode mud was often used incorrectly in this question.
   - Marks were awarded for recognising that even though the net $E^\circ$ for the cell is 0V, some voltage is required for the process - both needed to be mentioned for full marks.
   - Note that the fact that the reduction potential for copper ions is 0.34V is not an explanation for the low voltage necessary for electrefining.

QUESTION 6

Generally well done compared to other questions.

a) Marks awarded for adding a salt bridge and naming an appropriate electrolyte (1) as well as a description of why a salt bridge is necessary (1).
   - Common errors included omitting electrolyte.
   - Referring to electron transfer through salt bridge rather than ion transfer.
   - A number of students referred to the salt bridge maintaining “neutrality” of the cell rather than “electroneutrality”.
b) Generally well done.
d) Generally good, though a number of students referred to "stuff" being used up rather than reactants.

e) Few students received full marks for this and many did not identify three observable changes.
   - "Colour change" without orange - green was not sufficient to be awarded a full mark.
   - Volume does not increase due to water being a product of oxidation.
   - A wide range of valid observations were given credit in this question.

f) Generally poorly answered.
   - Many students misunderstood the question and added the two given reduction potentials given without any reference to zinc.
   - Many students gained one mark for addressing the first reaction but did not mention the second reaction.

**QUESTION 7**

Generally well answered.

a) Well done.
   - Using the \( m = \frac{Ar \times \text{t}}{F \times Z} \) was not appropriate in this question.

b) A common error was to forget that there are twice as many electrons as X atoms.
   - Some students had their mole-ratio inverted and were multiplying by two rather than dividing by two.
   - Part marks were awarded for calculating the molar mass of the metal X (118 g/mol), but this is not the answer to the question.
PART 2

CRITERION 6

QUESTION 8

a) A disturbing number of students misinterpreted the question and provided Boltzmann energy distribution diagrams rather than the requested potential energy diagram. Many students drew an endothermic diagram rather than the correct exothermic diagram. Marks were allocated for correct shape and labels. Markers were looking for the following annotations: $E_a$, $\Delta H$, products and reactants. The size of $E_a$ was not understood, nor was the correct sign given for the $\Delta H$. Diagrams were generally poorly annotated.

b) For this question students needed to directly relate the information about the spontaneous nature of the reaction and the low $E_a$, and explain how their diagram was consistent with the given information. Students also needed to explain how the continuous vigorous burning of phosphorus was related to the $\Delta H$ drawn on their diagram. Unfortunately many students made only very general comments about their diagrams rather than those specific to the situation.

c) Generally well done with most students collecting the full marks. Markers were looking for explanations about effective collisions, $E_a$, $E_k$, increasing surface area and increased exposed sites for effective collisions.

QUESTION 9

a) Students struggled with question 9 parts (a) and (c) although part (b) was generally well attempted.

- Most students were able to gain at least 1 mark out of 2 for part (a) by mentioning that the two reactions for “producer gas” and “water gas” were able to complement each other in the one furnace since the former was an exothermic reaction and the latter was an endothermic reaction.

- For the full 2 marks, some advantage needed to be stated.
b) This was answered well overall but there were some issues for students/teachers to be concerned about.

- Lack of units resulted in lost marks.

- Some students failed to recognise that CO₂ had two carbon to oxygen double bonds and were consequently out by 805 kJ in their calculations.

- Other students had trouble dealing with the fraction of \( \frac{1}{2} \) in front of the oxygen molecule in the given equation.

- Many students juxtaposed the data given in the table into their own unique calculations, either through rushing or not appreciating where the correct bonds appeared.

- Calculator errors were also prevalent. All these attracted penalties.

c) Very few students were able to make any sensible attempt for this section.

- Most students did not understand the question and it was obvious that their prediction was not based on any logic.

- The markers allocated 0.5 marks out of two for a successful prediction even if it did not have a correct explanation.

- The correct solution involved determining the energy released when 1 mole of hydrogen and 1 mole of carbon monoxide (from water gas) were combusted (510 kJ) and comparing it with when 2 moles of carbon monoxide from producer gas was combusted (580kJ).

- The correct solution required a similar number of moles of gases to be compared (either 1 mole of each, or 2 mole of each) hence the values of 255kJ and 290kJ were valid if comparing the energy released per mole of gas as asked in the question.
QUESTION 10

a) This question was poorly answered.
   - Students misinterpreted the question and failed to mention that it was only necessary to heat the catalyst in order to start the reaction, and that since the reaction in question was an exothermic reaction the process would become self-sustaining once initiated.
   - Many students answered this part in a similar manner to how the next part should have been answered.

b) Done successfully by most students.
   - Marks were deducted for failing to mention a lower $E_a$ was achieved with a catalyst present or that an alternative mechanism was introduced.

c) Whilst a large number of students recognised that the question was asking about entropy and enthalpy – they failed to successfully to describe the correct direction in which the two driving forces were acting.
   - Some students thought changing conditions such as pressure or temperature were the driving forces.

d) Poorly answered, with many students not understanding that having an excess amount of oxygen results in the equilibrium position adjusting to remove the excess oxygen, and that the forward reaction is favoured producing more NO as desired.
   - To score the full 2 marks, the desired outcome of producing more NO needed to be mentioned.

e) This question was reasonably answered by the majority of students who were able to state that by lowering the temperature, the equilibrium position adjusts by favouring the exothermic forward reaction to raise the temperature. This therefore shifts the equilibrium position to give more NO$_2$ as desired.
• Some students were less expansive with their answers and felt that to score the full 2 marks they simply needed to mention the acronym LCP without much additional information.

QUESTION 11

a) Many students didn’t truly understand the relevance of the numerical $K_c$ value given and that it really meant that there was a similar amount of both reactants and products at equilibrium with a little higher concentration of the product compared with the reactants.

b) Most students answered this question correctly regarding the forward and backward rates being equal at equilibrium, but failed to mention the lack of change in macroscopic properties.

c) Done well by a large majority of students. 1 mark was assigned for the explanation.

d) Done well by a majority of students with most students being awarded the full mark.

e) The concentration time graphs were poorly annotated. The majority of students failed to show the increase in pressure in (ii). Most students made a reasonable attempt; however, markers would appreciate greater care in drawing the diagrams. Markers awarded marks for correct shape and stoichiometric adjustments.

QUESTION 12

a) Students failed to answer this question well and if the species were correct then a reversible arrow wasn’t shown.

b) Extremely poorly answered and many students not understanding the definition of a Bronsted-Lowry acid.

c) Students did have a reasonable attempt at this question even if they didn’t understand part a) or b). To get the full marks students needed to show an expression for the acidity constant ($K_a$) and they needed to make mention of any assumptions they were making when simplifying expressions. Since this question had several stages to its solution, it was possible to be awarded part marks for a logical follow through even if the final answer was incorrect. This highlights the importance of clear and well communicated working out.
PART 3
CRITERION 7

GENERAL COMMENTS

Overall, students found Part 3 difficult. When answering questions, especially those requiring explanation and reasoning, students who did well, communicated their knowledge and understanding by addressing the focus or stimulus of the question and using detailed language.

In questions involving the properties and structures of organic materials, students benefit from showing the full structure of organic molecules. In this examination, markers chose to overlook the instruction to give a semi-structural chemical equation due to the sheer volume of responses that gave the preferred full structural representation of organic molecules. Marks were not given for empirical or molecular formulae. Students are also encouraged to familiarise themselves with, and refer to, the information given on the Information Sheet, such as the flowchart of organic reactions of aliphatic compounds.

In questions involving the Periodic Table and properties of gases, students who did not do well used personification to explain trends or gave indirect answers (e.g. chlorine “wants” to gain electrons). Students are encouraged to read the question carefully and ensure they address the question in their answer by using specific relevant language.

QUESTION 13

• While most students attempted this first question, at least identifying the two straight chain isomers of butene, many struggled to distinguish between the two isomers using the reaction with hydrogen chloride gas.
• Students who attempted to fully answer this question had difficulty ascertaining the end-point required by the examiner, giving elaborate and gallant reaction sequences.
• Common mistakes involved overlooking the stimulus of two straight chain isomers and omission of a structural equation.
• Students who recognised the two possible products of the reaction between the butene isomer and HCl(g) gained full marks.
QUESTION 14

a) Most students identified isomer P as a ketone. Some students struggled to use the IUPAC system when numbering the carbon chain, although the position of the methyl side chain and carbonyl function group is redundant in the case of this isomer.

b) Most students used the addition of an oxidiser to distinguish between isomer P and isomer Q.
   - Some students did not give a specific oxidiser, most omitted $H^+_{(aq)}$ when giving $\text{MnO}_4^-_{(aq)}$ or $\text{Cr}_2\text{O}_7^{2-}_{(aq)}$ as their answer, and too many students did not consider an observation of their nominated chemical test.
   - Of the students who chose $\text{MnO}_4^-_{(aq)}$ or $\text{Cr}_2\text{O}_7^{2-}_{(aq)}$, most did not use the obvious colour changes that occur when these reagents undergo reduction.
   - Instead, many students chose to test the pH of an already acidified solution in order to determine the presence of the carboxylic acid oxidation product in the case of the aldehyde, isomer Q!

c) This question was answered well, although some students just wrote $\equiv\text{O}$, rather than C=O, which was not given any marks.

d) (i) Two fragments with a m/z = 43 were required for full marks. Fragment notation requires some clarification and structural formulae is always preferable.
   (ii) Most students identified Spectrum 1 gaining 1 mark, however, many students struggled to explain their choice. Superior answers carefully considered the data tables given in the question.

e) This question was not answered well.
   - Too many students gave the generic statement of "like dissolves like" but failed to elaborate on the specific attraction between isomer P and water molecules that results in the solubility of this isomer in the solvent, water.
   - Superior answers outlined why isomer P is a polar molecule.
Alarmsingly, some students drew HO₂ structures or discussed the attraction between O²⁻ and H⁺ species.

Most students attempted to address the reference in the question to the slight solubility of isomer P in water.

QUESTION 15

a) This question was answered well, although a few students forgot to include the carboxyl carbon in the counting of the carbon chain of this molecule.

b) (i) Students are encouraged to use the Information Sheet as their first point of reference for straightforward questions such as this question (a significant minority of students are still confusing ammonia and ammonium).

(ii) This question was generally answered well, and most students identified the functional groups, carboxylic acid and amine, which were both required for full marks.

• It was pleasing to see a number of students identified compound T as an amino acid.

• Too many students confused the amine and amide functional groups.

c) (i) Disappointingly, the vast majority of students incorrectly identified compound S as a diprotic acid.

(ii) If students answered incorrectly in part (i), error carried forward was generally not fully awarded as chemical equations were not balanced nor demonstrated the behaviour of compound S as an acid.

• Disturbingly, it appeared that a number of students believed that the hydroxyl group of compound S was a hydroxide ion and some went as far as suggesting that this group ‘neutralised’ the carboxyl group!

• Superiors answers included an equilibrium sign and the hydronium ion, H₃O⁺(aq).

d) Most students attempted this part, and the drawing of the ester product was generally well done, although, the halo group was sometimes omitted.

• The vast majority of students did not recognise or acknowledge that this esterification reaction (Fischer) is an equilibrium system and/or did not include the H₂SO₄ catalyst.
• Too many students omitted the water product.

e) This question was confusing for students as NaOH could react with both the halo group and the carboxyl functional group.

• Students who recognised both reactions gained full marks due to the high mark allocation for this question.

• Students are reminded to include the charges on the RCOO\(^-\)…Na\(^+\) part of the alkanoate molecule.

• In their efforts to write a semi-structural equation, some students incorrectly wrote a covalent bond in NaOH.

QUESTION 16

a) This question was not well answered.

• Too many students used personification and the erroneous ‘octet rule’ to explain Periodic Table trends, such as ‘sulfur only needs two electrons to complete its outer shell whereas silicon needs four electrons, therefore sulfur is more electronegative than silicon as it has a greater urge for electrons.’ (In addition, statements of Periodic Table trends by way of an explanation were not accepted.)

• Students who did well on this question tied together the nuclear charge and similar shielding of silicon and sulfur to explain the difference in electronegativity of these two elements.

• A few students mentioned effective nuclear charge but didn’t explain this concept.

b) For full marks in this question, markers were looking for the recognition that p-block elements were classified as such because the valence electrons of these elements inhabited the p subshell.

c) This question was well done.

• Marks were not given for an electron configuration of 2-8-2 (nor 2-8-3!) and some students missed the charge on the ion.

• The previous noble gas shorthand notation of [Ne] 3s\(^2\), was accepted by markers for this difficult paper, but students are encouraged to give full electron configurations when it is the only answer required of a given question.
d) A pleasing number of students attempted this question.
   - Inclusion of the gaseous state for this ionisation process would have been preferred by markers.

e) Students had mixed success on this question.
   - Students who did well on this question clearly recognised the removal of a 3s electron from Al\(^+\) and 3p electron from Si\(^+\), acknowledged that according to nuclear charge, Si\(^+\) should show a greater second ionisation energy than Al\(^+\) and attributed the observed anomaly to the higher energy level or greater distance of the 3p electron of Si\(^+\) from the nucleus.
   - Many students credited the difference in ionisation energy to the relative stability of a complete 3s subshell compared to an incomplete 3p subshell and were given part marks.

QUESTION 17

a) Many students outlined the excitation and promotion of electrons and there was evidence of prepared answers; however, most students did not go on to answer the question.
   - Students who did well on this question showed that they understood that electrons can only inhabit quantized energy levels and that the certain frequencies of light emitted corresponded to the difference in energy between these energy levels.
   - A few students included the formula \(\Delta E = hf\), but did not explain its relevance. Some students mentioned photons and a few students confused wavelength and frequency. No students mentioned that the difference in energy between energy levels is different for different atoms.

b) This question was well done with most students identifying helium and achieving one mark.
   - In terms of the explanation, many students mentioned the 2\(^+\) nuclear charge but ignored the absence of shielding and proximity to the nucleus of the electrons.
QUESTION 18

a) When answering this question most students identified the two main assumptions, namely the negligible attractive forces between ideal gas particles and the negligible gas particle volume of an ideal gas.

- Other assumptions were stated that were less relevant - some students seemed to be inferring that an ideal gas and a real gas were two different types of gases.

b) It was pleasing in this question that many students made the link between temperature and gas particle kinetic energy.

- A significant minority of students chose to answer this question by first writing about decreasing, rather increasing, temperature.

c) Most students appeared to assume higher external pressures and a compressible container and wrote about a subsequent decrease in volume, whilst some students simply began the question by mentioning an increase in gas concentration.

- Whatever their initial approach, the majority of students noted the decrease in distance or closer proximity between gas particles and subsequent increase in the influence of intermolecular forces.
- It was pleasing to read that a few students who stated that higher pressure would result in a decrease in gas volume, went on to explain that the volume of the N₂ gas particles would then become significant.
- Many students spoke about ‘interactions’ between gas particles which the markers felt was a far too generic term.

Unfortunately, in Part (b) and Part (c) many, many students interpreted these questions as collision theory questions, mentioning effective collisions leading to bonds breaking and N₂(g) molecules reacting! Students are encouraged to always consider the criterion being assessed to assist in their interpretation of a question; there were no reactions occurring between N₂(g) molecules.
PART 4

CRITERION 8

GENERAL COMMENTS:

This section of the paper proved to be challenging for a large number of candidates. It was apparent that many students either misread questions or simply did not understand what it was that was being asked of them. Students benefited from attempting questions that they might have been unsure about, and “error carried forward” was employed widely, giving credit for correct working in good faith despite an early error.

QUESTION 19

a) This was a simple question that was generally well answered. The majority of candidates received at least part marks for this question.

- Marks were awarded for correctly calculating the number of moles of both species present.
- For full marks, students had to demonstrate that they had used the molar ratio (2:1) and show that MgCO₃ was in excess, not simply state it.

b) This part of the question was poorly answered, with few candidates receiving full marks.

- There was no clear pattern of responses in this question, suggesting that students were unsure what the question was asking of them.
- Most students did not calculate the theoretical yield (100%) of hydrated magnesium chloride.
- It seemed that many students did not realise that there was a link between parts (b) and (a) in the question.

QUESTION 20

a) This was an uncomplicated question and was well answered by the majority of candidates. For full marks students needed to include units and the correct sign (-) for the enthalpy value.
b) Students found this question difficult. It was common for the prediction to be correct but the explanation to be contradictory. Marks were not awarded in these instances.

c) See part (b). Additionally, explanations were difficult to interpret due to the restriction of “greater than”, “the same as” or “less than” as the predictions. It was apparent that many students understood the effect on the enthalpy, but chose alternative predictions in their own words. Students were not penalised for this and marks were awarded on merit.

QUESTION 21

a) This was an accessible question for most students and was answered well.

- Many students opted to use $PV = nRT$ rather than the simpler approach of dividing $67.3 \text{ mL} (0.0673 \text{ L})$ by the molar volume of a gas at SLC (24.5 L/mol). Full marks were awarded for correct answers.

b) This question was, surprisingly, poorly answered.

- It was apparent that most students did not understand the concept of water vapour pressure, with many choosing to add it to the total pressure and others simply ignored it.
- A minority of students subtracted the water vapour pressure, which was the correct approach.
QUESTION 22

a) Students generally answered this question well and were able to demonstrate a solid understanding of the relationship between the mole ratio in a chemical equation and the equilibrium constant expression.

- A significant number of students forgot to include equilibrium arrows, limiting their score to 0.5/1 mark and a small number of students confused the reactants and products. To score full marks students needed to simply write $2G \leftrightarrow 3E + F$.

b) To score full marks for question b(i) students had to first calculate $Q$, and then compare this with the quoted value of $K_c$ to conclude that the reaction was not at equilibrium. For part (ii) they simply had to identify that the reverse reaction was favoured. Students generally answered this question well.

c) To score full marks students were required to:

- Calculate the number of moles of each species present at equilibrium
- Calculate the concentration of each species present at equilibrium
- Calculate $K_c$ using the equilibrium constant expression provided.

This question was answered correctly by many students, and typical errors involved:

- Incorrectly using the mole ratio in the equation to calculate equilibrium number of moles (ie making mistakes in the “ICE” table).
- Forgetting to calculate equilibrium concentration and instead using #mole to calculate $K_c$.
- Confusing or forgetting to take the indices into account when calculating $K_c$. 
QUESTION 23

a) To score full marks students were required to:

- Calculate the number of mole of HCl used.
- Calculate the number of mole of Ca(OH)$_2$.
- Calculate concentration of Ca(OH)$_2$.
- Quote their answer to 3 significant figures.

This question was answered correctly by many students, and typical errors involved:

- Forgetting to use the mole ratio in the balanced chemical equation.
- Quoting their answer to 2 or 4 significant figures.

Some students rounded numbers too soon and to far too great an extent, and some did not quote units with their answers.

b) To score full marks students were required to justify their conclusion that the solution was not saturated. Some ways in which this was successfully done:

- Calculating the concentration in mol/L of a saturated solution and comparing this to the concentration of the solution from part (a).
- Calculating the number of moles present in 25mL of a saturated solution and comparing this to their working in part (a).
- Calculating the mass of Ca(OH)$_2$ present in 100mL of their titrated solution and comparing this to the saturated solution.

Incorrect responses to part (a) were taken into account when marking part (b) and students were not penalised twice.

- Some students calculated a value (of either mass or concentration) larger than that given for a saturated solution but drew the wrong conclusion. Partial marks were awarded if their calculation was correct.
c) To score full marks students were required to:

- Calculate the concentration of Ca(OH)$_2$ in the saturated solution given the concentration in g/100 mL (some students had already done this in their answer to part (b).
- Calculate the concentration of OH$^-$ ions.
- Calculate the pH of the solution by using either the $K_w$ expression to first find [H$^+$] or by calculating pOH and then using pH + pOH = 14.

Many students scored 3 out of 4 for this question because they:

- Forgot to realise that [OH$^-]=2\times[Ca(OH)_2]$.
- Used [Ca(OH)$_2$] from their answer to part (a) rather than from the saturated solution.

**QUESTION 24**

In general this question was very poorly answered.

a) To score full marks students were required to:

- Write a balanced chemical equation to know the mole ratio HCl : MgO
- Calculate n(HCl) and use this to calculate n(MgO).
- Use $q = m\Delta T$ to calculate the energy released by the reaction.
- Use $\Delta H = q/n$ to calculate the energy change in kJ/mol (or J/mol)
- One mark was awarded for correctly calculating n(HCl).
- One mark was awarded for correctly calculating n(MgO).
- One mark was awarded for correctly calculating $q$.
- One mark was awarded for correctly calculating $\Delta H$ although its sign and units were disregarded.
- Errors in one part of the solution were not penalised twice.
Most students found this question difficult, and the following issues were common.

Students:

- Typically had no idea that “m” in \( q = mC\Delta T \) should be taken as 50.0 from the volume of the reaction mixture. Instead they tried to calculate the mass of water produced in the reaction, or the mass of HCl used in the reaction (by a separate calculation), or the mass of MgO used in the reaction… These were very common errors.
- Confused 50.0 giving Joules with 0.050 giving kJ when using \( q = mC\Delta T \)
- Used \( n(\text{HCl}) \) instead of \( n(\text{MgO}) \), or various other values such as the mass of MgO or the mass of HCl when calculating \( \Delta H \).

b) To score full marks students were required to write a balanced chemical equation for the reaction of MgO with HCl and to include the DH term. This could be done as:

- \[
\text{MgO(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O(l)} + 89 \text{kJ}
\]

OR

- \[
\text{MgO(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O(l)} \quad \Delta H = -89 \text{kJ/mol} \quad (- 0.5 \text{ marks if this value was positive}).
\]

States were not required and students were not penalised twice for an incorrect answer to part (a).

Typical mistakes in this question:

- Incorrect formula for MgCl₂
- Incorrect balancing
- Incorrect products of the reaction including H₂, O₂, OH⁻, H, O.
QUESTION 25

Students could obtain full marks by simply calculating RAM or molar mass of Xe as follows:

- \[5.894 \times 22.41 = 132.1 \text{ g/mol.}\]

OR

- use \(PV = nRT\) to calculate \(n\) (many students did not realise that the volume was 1 L from the density value)

- calculate \(M_r\) using mass/number of moles.

Because the element was identified as Xe it was impossible to know which students were correctly analysing units to derive a solution to the problem, and which were multiplying available numbers together to arrive at a value close to that quoted for Xe on the Periodic Table.

A common error in using \(PV = nRT\) in this question was the use of 298 rather than 273 for \(T\).
reaction

ne: the catalyst is regenerated
in reaction not to be reversed.
Infection may now be eliminated
and bacteria will be destroyed.
Infection may now be eliminated
following exposure within 10 days.

Reactor E: Reaction (1)
Expression: CO + H₂O → CO₂ + H₂

[Diagram]

(9) E. Reaction: Right hand rule.
(10) Reaction: Acidic exchange.
(11) Energy & forming equation.
(12) Experimental conditions.
(13) Reaction (1) - (10)

[Equation]

CO₂ + H₂O → CO₂ + H₂
CO₂ + H₂O → CO₂ + H₂
CO₂ + H₂O → CO₂ + H₂
CO₂ + H₂O → CO₂ + H₂

(14) Reaction (1) - (10)

(15) Reaction: Acidic exchange.
(16) Energy & forming equation.
(17) Experimental conditions.
(18) Reaction (1) - (10)

[Diagram]

(19) E. Reaction: Right hand rule.
(20) Reaction: Acidic exchange.
(21) Energy & forming equation.
(22) Experimental conditions.
(23) Reaction (1) - (10)
The text in the image appears to be a mixture of mathematical equations and natural language. Due to the complexity and the blend of both, it is challenging to transcribe accurately without the context or the full document. It seems to involve chemical or scientific calculations and descriptions.

For a more precise transcription, additional context or a clearer view of the document would be helpful. This text includes symbols, equations, and possibly chemical reactions or calculations, which require a specific expertise to interpret accurately.