Student Number

ST. ALOYSIUS' COLLEGE

Final Examination 2022

Year 11 Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper

Total Marks: 75

SECTION I – 20 marks

- Attempt Questions 1–20
- Allow about 30 minutes for this section

SECTION II – 55 marks

- Attempt Questions 21-33
- Allow about 1 hour and 30 minutes for this section

SECTION I

20 marks
Attempt Questions 1–20
Allow about 30 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

1 Which of the following techniques would be used to obtain sodium chloride from sea water?

A. distillation
B. evaporation
C. gravity filtration
D. vacuum filtration

2 Elements X and Y are in the same period of the Periodic Table and have 2 and 5 electrons respectively in their outer shell. What is the likely formula of the compound they form together?

A. X_2Y_3
B. X_3Y_2
C. X_2Y_5
D. X_5Y_2

3 Which of the following gases will occupy 22.71 L at 100 kPa and 0°C (273.15 K)?

A. 5.0 g of H_2
B. 20 g of O_2
C. 50 g of NO_2
D. 64 g of SO_2

4 What is the molar mass of $KAl(SO_4)_2 \cdot 12H_2O$?

A. 258.22 g mol^{-1}
B. 378.34 g mol^{-1}
C. 447.40 g mol^{-1}
D. 474.46 g mol^{-1}

5 Which of the following chemical equations is balanced?

A. $Fe(OH)_3(\boldsymbol{aq}) + 2H_2SO_4(\boldsymbol{aq}) \rightarrow Fe_2(SO_4)_3(\boldsymbol{aq}) + 3H_2O(\boldsymbol{l})$

B. $Zn(\boldsymbol{s}) + 2HCl(\boldsymbol{aq}) \rightarrow ZnCl_2(\boldsymbol{aq}) + H_2(\boldsymbol{g})$

C. $C_3H_7OH(\boldsymbol{l}) + 5O_2(\boldsymbol{g}) \rightarrow 3CO_2(\boldsymbol{g}) + 4H_2O(\boldsymbol{g})$

D. $KNO_3(\boldsymbol{s}) \rightarrow KNO_2(\boldsymbol{s}) + O_2(\boldsymbol{g})$

6 How many chloride ions are in 0.100 mol of magnesium chloride?

A. 6.02×10^{22}

B. 1.20×10^{23}

C. 6.02×10^{23}

D. 1.20×10^{24}

7 Which row of the table correctly identifies a typical physical property of a metal element and a typical physical property of a non-metal element?

	Physical property of metal	***Physical property of non-metal***
A.	low boiling point	poor conductor of electricity
B.	low density	malleable
C.	high density	low melting point
D.	malleable	high density

8 Which of the following pairs of aqueous solutions will produce a precipitate when mixed?

Solubility of ionic compounds	
Soluble	*Insoluble*
All Group 1 and NH_4^+ compounds	Phosphates (except Group 1 and NH_4^+)
All nitrates	Hydroxides (except Group 1 and NH_4^+, Ba^{2+}, Ca^{2+}, Sr^{2+}
Chlorides (except Ag^+, Pb^{2+})	
Sulfates (except Ag^+, Pb^{2+}, Ba^{2+}, Ca^{2+})	

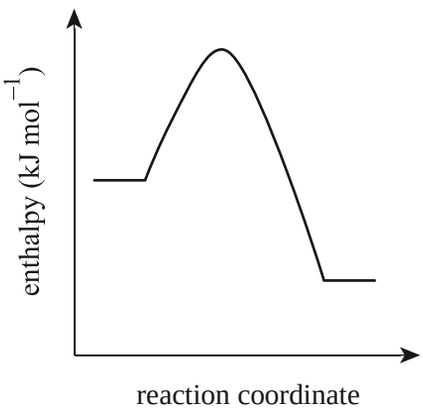
A. $BaCl_2$ and $Zn(NO_3)_2$

B. CH_3COOAg and $CaCl_2$

C. $MgSO_4$ and KCl

D. NaOH and HNO_3

9 An energy profile diagram for a reaction is shown.



Which of the following statements is correct?

A. The energy of the reactants is lower than the energy of the products.
B. The energy of the reactants is the same as the energy of the products.
C. The diagram represents the enthalpy change of an exothermic reaction.
D. The diagram represents the enthalpy change of an endothermic reaction.

10 Which of the following correctly lists the metals from most reactive to least reactive?

A. potassium, iron, nickel, silver
B. zinc, iron, copper, lead
C. potassium, magnesium, barium, aluminium
D. silver, copper, lead, sodium

3

11 Zinc metal reacts with sulfuric acid to produce zinc sulfate and hydrogen gas according to the following chemical equation.

$$Zn(\boldsymbol{s}) + H_2SO_4(\boldsymbol{aq}) \rightarrow ZnSO_4(\boldsymbol{aq}) + H_2(\boldsymbol{g})$$

What type of reaction is this?

A. redox
B. precipitation
C. decomposition
D. combustion

12 A solution is prepared by dissolving 2.43 g of sodium hydroxide in enough water to make a 500 mL solution.
What is the concentration of hydroxide ions in the solution?

A. 0.0122 mol L^{-1}

B. 0.0608 mol L^{-1}

C. 0.1215 g mol^{-1}

D. 0.1215 mol L^{-1}

13 What is the oxidation state of sulfur in $Na_2S_2O_4$?

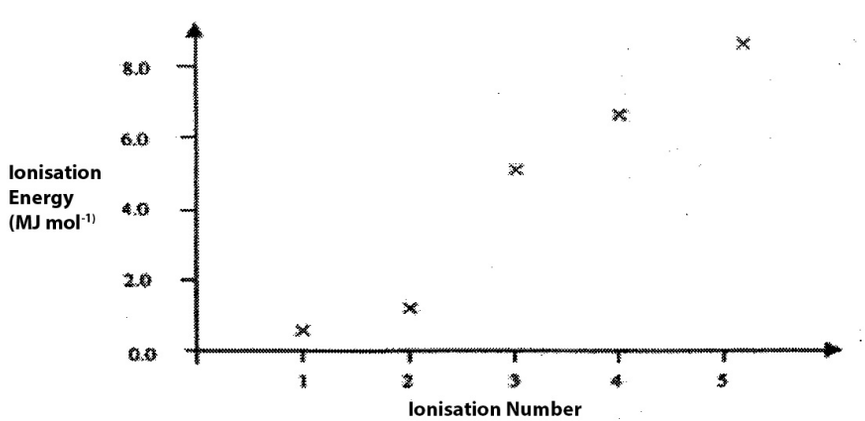
A. –2

B. +3

C. +4

D. +6

14 An element has the first five successive ionization energies as on the graph below.



Which one of the following is most likely to be the element?

A. Sodium

B. Calcium

C. Aluminum

D. Phosphorus

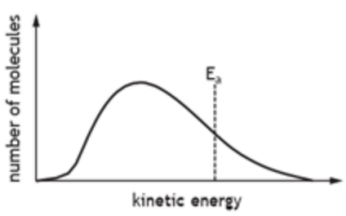
15 The ion $^{40}_{20}Ca^{2+}$ contains:

A. 20 protons, 20 neutrons and 20 electrons
B. 18 protons, 20 neutrons and 20 electrons
C. 20 protons, 18 neutrons and 22 electrons
D. 20 protons, 20 neutrons and 18 electrons

16

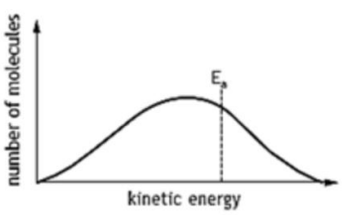
The diagram below shows the distribution of kinetic energies for a reaction involving two gases.

The activation energy for the reaction is shown as Ea on the diagram.

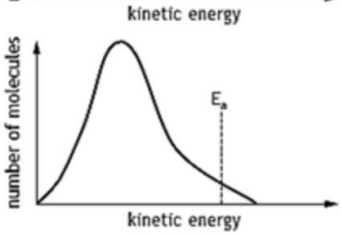


Which diagram below best shows the effect of increasing temperature on the same system?

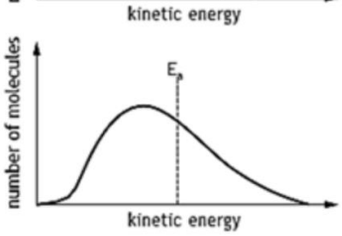
(A)



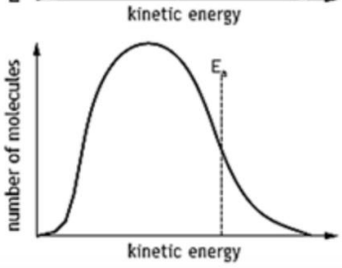
(B)



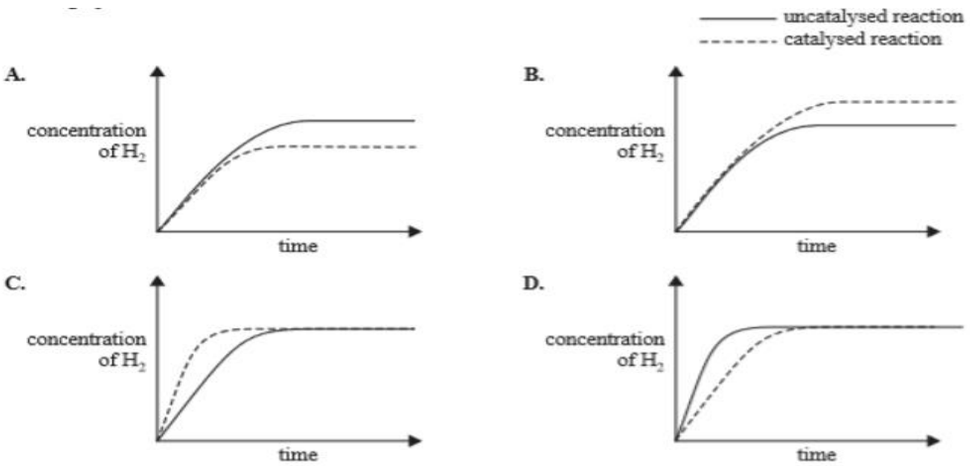
(C)



(D)



17 In a series of tests, a reaction which produces hydrogen gas is carried out in a sealed container. The temperature and volume of the container are not changed. The change in hydrogen concentration with time between an uncatalysed and a catalysed reaction is represented by a graph.



Which of the above graphs is correct?

A. A.
B. B.
C. C.
D. D.

18 Given that 54.0 kJ of heat energy is required to convert 1.00 mole of liquid water to steam at 100ºC, what is the total amount of heat energy, in kilojoules, released when 100 g of steam at 100ºC is cooled to water at 20ºC?

A. 3.4×10^1 kJ
B. 2.7×10^2 kJ
C. 1.5×10^2 kJ
D. 3.3×10^2 kJ

19 How can the reaction of calcium carbonate to form carbon dioxide and calcium oxide be described?

I – endothermic
II – combustion
III – synthesis
IV – decomposition

A. I and III only
B. I and IV only
C. II and IV only
D. IV only

20 Solid copper is added to a solution of zinc nitrate at standard conditions. Which of the following observations would be most likely?

A. The blue precipitate forms on the grey solid and the solution turns colourless.

B. The solid copper dissolves in the colourless solution and a grey precipitate is formed.

C. The solid copper dissolves and a blue solution is formed.

D. No visible reaction occurs.

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Student Number

Section II Answer Booklet

Section II

55 marks
Attempt Questions 21-33
Allow about 1 hour and 30 minutes for this section

Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (1 marks)

Write the (spdf) electron configuration for the following isotope:

Isotope	*Electron configuration*
$^{81}_{35}Br$	

Question 22 (6 marks)

Iodine-131 is used in medicine. It emits beta particles as it decays into a stable daughter isotope.

(a) Complete the nuclear equation for the beta decay of Iodine-131 (1 mark)

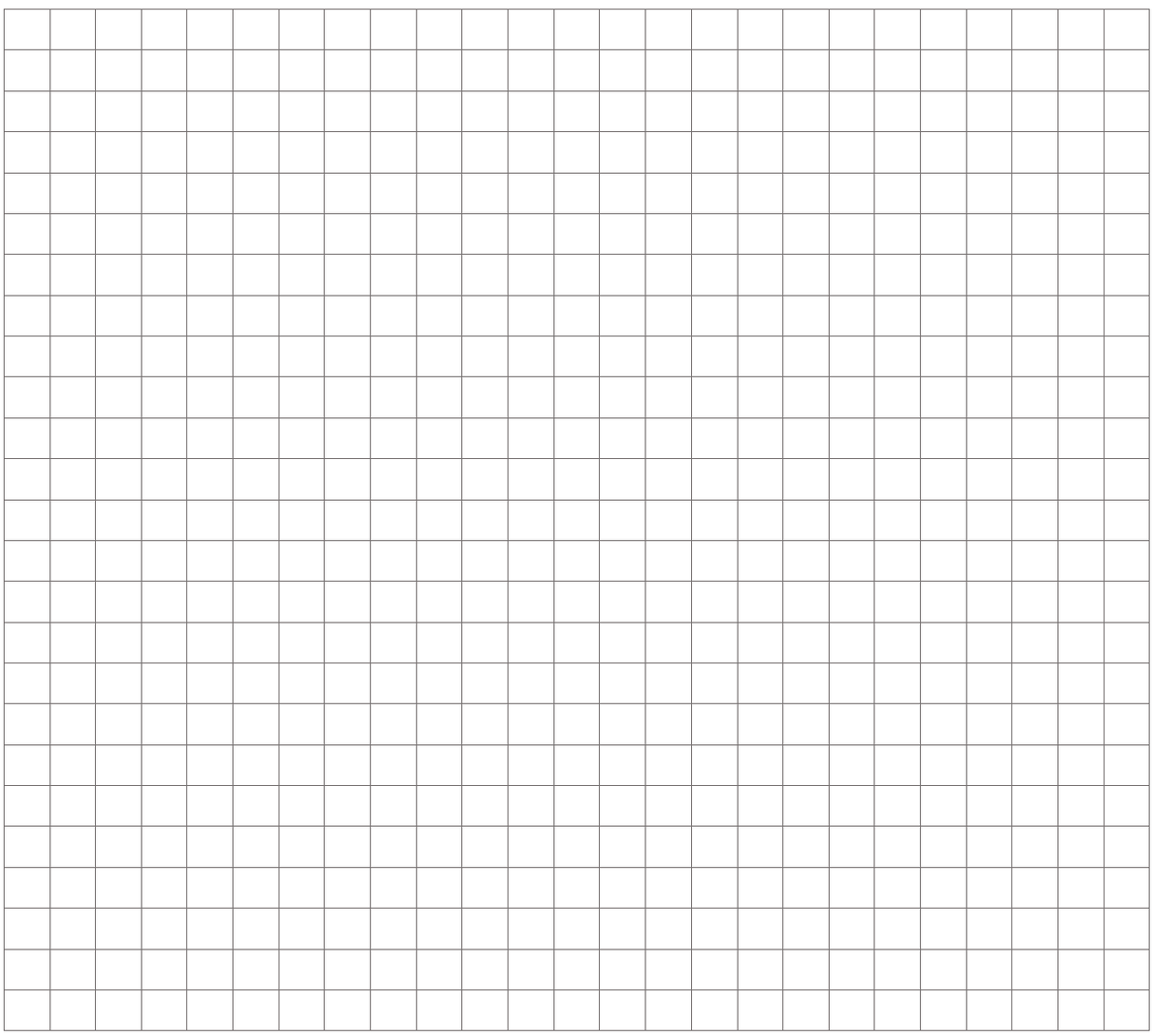
$$^{131}_{53}I \rightarrow \_\_\_\_ + {}^{0}_{-1}e$$

Question 22 continues on the next page

(b) The table shows how the mass of an original 25 mg sample of Iodine-131 changes over time. (3 marks)

Mass (mg)	25	16.3	10.8	7.0	4.9	3.2
Time (days)	0	5	10	15	20	25

Draw a graph showing the decay of Iodine-131 in the grid below:



Question 22 continues on the next page

(c) Use the graph to determine the half-life of Iodine-131. Show working out. (2 marks)

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Question 23 (4 marks)

Dichloromethane and water are liquids that are immiscible with each other. Some of their properties are shown in the table.

	Boiling point (°C)	***Density (g mL^{-1})***
Dichloromethane	39.6	1.33
Water	100	1.00

A chemist finds a bottle containing dichloromethane and water and needs to determine whether she should use a separating funnel or distillation to separate the liquids.

Assess the effectiveness of each technique techniques when separating dichloromethane and water.

Question 24 (3 marks)

The table shows some information about the compounds dichloromethane (CH_2Cl_2), propane (C_3H_8), water (H_2O) and tetrafluoromethane (CF_4).

Compound	***Molar mass (g mol $^{-1}$)***	***Boiling point (°C)***
CH_2Cl_2	84.9	39.60
C_3H_8	44.0	–42.00
H_2O	18.0	100.00
CF_4	88.8	–127.80

Explain why water has the highest boiling point out of the four compounds despite having the smallest molar mass.

Question 25 (4 marks)

"Sodium and chlorine are the two most reactive elements in Period 3 of the Periodic Table, but they are highly reactive for different reasons related to their unique atomic structure."

Explain this statement and outline the reasons for the reactivity of sodium and chlorine gas.

Question 26 (3 marks)

A bottle of oven-cleaning solution contains sodium hydroxide. The volume of the bottle is 1.50 L and the concentration of sodium hydroxide in the solution is 2.65 mol L^{-1}.

(a) Calculate the mass of sodium hydroxide in the bottle. (2 marks)

(b) Some of the solution is used and the remaining volume of solution in the bottle is 0.50 L. Water is added to the bottle so that the volume of the solution returns to 1.50 L.

Calculate the molar concentration of sodium hydroxide in the dilute solution. (1 mark)

Question 27 (3 marks)

Butane (C_4H_{10}) is one of the components of liquefied petroleum gas (LPG). It undergoes complete combustion in excess oxygen.

A sample of butane undergoes complete combustion in excess oxygen at 200°C and 182.4 kPa, producing 35.0 L of carbon dioxide.

Calculate the mass of butane reacted. Include a balanced chemical equation in your answer.

Question 28 (5 marks)

13.00 g of hydrogen gas is reacted with 11.68 g of solid iodine I_2 to produce hydrogen iodide gas.

(a) Identify the limiting reagent and the excess reagent. (2 marks)

(b) Calculate the amount of moles that the excess reactant is in excess. (1 mark)

(c) Calculate the mass of the hydrogen iodide gas produced. (2 marks)

Question 29 (7 marks)

Ethylene glycol is a chemical used to depress the freezing point of water in products marketed as 'antifreeze'. It is a compound composed of C, H and O only.

A 44.80 g sample of this chemical was completely oxidized to form 61.6 g of carbon dioxide and 37.8 g of water.

(a) Calculate the mass of carbon and hydrogen in this sample. (4 marks)

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(b) Determine the mass of oxygen in antifreeze and hence the empirical formula of the compound. (2 marks)

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(c) If the molar mass of the compound is approximately 62 g mol^{-1}, determine the molecular formula of antifreeze. (1 mark)

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Question 30 (7 marks)

A group of students were investigating the use of different metals and their solutions in galvanic cells. They were provided with strips of magnesium, lead and silver and solutions of magnesium nitrate, lead nitrate and silver nitrate. All the solutions had 1.0 mol L^{-1} concentration.

(a) Which combination of metals has the highest potential difference? (1 mark)

_____

(b) Draw a diagram of a galvanic cell that uses the metals identified in part (a) and write a balanced chemical equation for the net ionic reaction that occurs in the cell. In your diagram, identify and label the electrodes, electrolytes and salt bridge, and label the electron flow. (5 marks)

Question 30 continues on the next page

(c) Calculate the cell potential of the galvanic cell. (1 mark)

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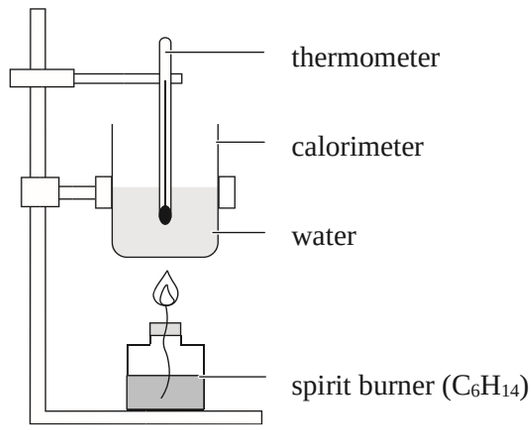
Question 31 (5 marks)

A catalyst can increase the rate of a chemical reaction.

Identify TWO other factors that can increase the rate of a reaction and explain, using collision theory, how these factors influence the rate of the reaction.

Question 32 (4 marks)

A student sets up the following experiment to determine the amount of energy that would be released by the combustion of a sample of hexane (C_6H_{14}).



The following data was recorded at the start of the experiment.

Mass of hexane burned	2.38 g
Mass of water heated	600 mL
Initial temperature of water	23.0°C

If the heat of combustion of hexane is –4163 kJ mol^{-1}, calculate the final temperature of the water.

Question 33 (3 marks)

Potassium chloride is a water-soluble ionic salt. When 1.45 g of potassium chloride is dissolved in 50.0 mL of water, the temperature of the water decreases by 1.60°C.

Calculate the molar enthalpy of the reaction.

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End of paper

Section II - Extra writing space

If you use this space, clearly indicate which question you are answering.

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If you use this space, clearly indicate which question you are answering.

2022 Year 11 Chemistry Yearly Exam Marking Guidelines

1	**B**
2	**B**
3	**D**
4	**D**
5	**B**
6	**B**
7	**C**
8	**B**
9	**C**
10	**A**
11	**A**
12	**D**
13	**B**
14	**B**
15	**D**
16	**A**
17	**C**
18	**D**
19	**B**
20	**D**

Question 21 (1 marks)

Write the (spdf) electron configuration for the following isotope:

Isotope	*Electron configuration*
$^{81}_{35}Br$	

Provides correct information for the spdf notation	1

Sample answer:

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

Question 22 (6 marks)

Iodine-131 is used in medicine. It emits beta particles as it decays into a stable daughter isotope.

(a) Complete the nuclear equation for the beta decay of Iodine-131 (1 mark)

$$^{131}_{53}I \rightarrow \_\_\_\_ + {}^{0}_{-1}e$$

Criteria	Marks
• Completes nuclear equation correctly	1

Sample answer:

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

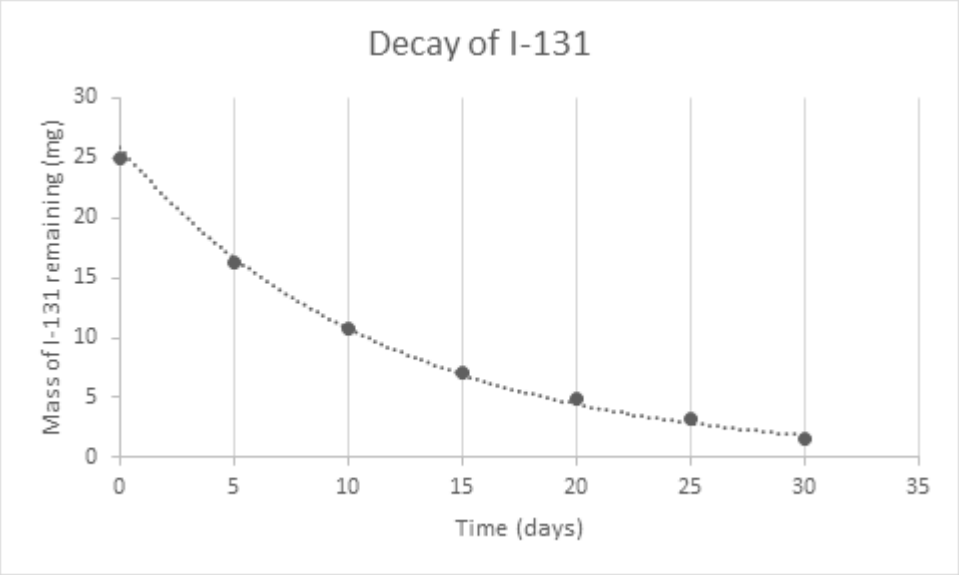
(b) The table shows how the mass of an original 25 mg sample of Iodine-131 changes over time. (3 marks)

Mass (mg)	25	16.3	10.8	7.0	4.9	3.2
Time (days)	0	5	10	15	20	25

Draw a graph showing the decay of Iodine-131 in the grid below:

Criteria	Marks
• Plots mass of Iodine-131 (vertical axis) against time (horizontal axis) accurately • Labels both axes including relevant units • Places even scale on each axis • Gives graph a title • Correct physical quantity on the correct axes • Curve of best fit	3
• Provides a substantially correct graph	2
• Provides some basic features of the graph	1

Sample answer:



(c) Use the graph to determine the half-life of Iodine-131. Show working out. (2 marks)

Criteria	Marks
• Shows how half-life of Iodine-131 was determined from the graph and includes interpolation on the graph • Gives half-life of Iodine-131 as 8 days ±0.1 • Uses more than one point of reference	2
• Gives half-life of Iodine-131 as 8 days ±0.1	1

Sample answer:

From the graph it can be determined that after 8 ± 0.1 days the mass of Iodine-131 drops from 25 mg to 12.5mg. After 16 days the mass drops from 12.5 mg to 6.25 mg. The half-life is there for 8 ±0.1 days.

Question 23 (4 marks)

Dichloromethane and water are liquids that are immiscible with each other. Some of their properties are shown in the table.

	Boiling point (°C)	***Density (g mL^{-1})***
Dichloromethane	39.6	1.33
Water	100	1.00

A chemist finds a bottle containing dichloromethane and water and needs to determine whether she should use a separating funnel or distillation to separate the liquids.

Assess the effectiveness of each technique techniques when separating dichloromethane and water.

• States that a separating funnel AND distillation are both effective techniques. AND • Assesses the effectiveness of a separating funnel based on different densities and immiscibility AND • Assesses the effectiveness of distillation based on a large difference in boiling points	4
• States that a separating funnel AND distillation are both effective techniques. AND • Assesses the effectiveness of a separating funnel based on different densities and immiscibility AND • Assesses the effectiveness of distillation based on a large difference in boiling points But does not include a few important points, eg. The two liquids are immiscible and can be separated using a separating funnel	3
States that a separating funnel OR distillation is an effective technique. AND • Assesses the effectiveness of the technique	2
Provides some relevant information	1

Sample answer:

Dichloromethane and water are immiscible, so they do not mix and, instead, form separate layers. As a result, they can be separated effectively with a separating funnel. The density of dichloromethane is higher than the density of water, so the dichloromethane will be the lower layer and the water will be the upper layer. The liquids could also be separated effectively

through distillation. They have a large difference in boiling points. Dichloromethane has a lower boiling point than water (39.6°C). As such, it will be the first fraction to be collected during distillation.

Question 24 (3 marks)

The table shows some information about the compounds dichloromethane (CH_2Cl_2), propane (C_3H_8), water (H_2O) and tetrafluoromethane (CF_4).

Compound	***Molar mass (g mol $^{-1}$)***	***Boiling point (°C)***
CH_2Cl_2	84.9	39.60
C_3H_8	44.0	–42.00
H_2O	18.0	100.00
CF_4	88.8	–127.80

Explain why water has the highest boiling point out of the four compounds despite having the smallest molar mass.

• States that water is polar and the other compounds are slightly polar or non-polar. AND • Explains why the intermolecular bonding (Hydrogen bonding) in water results in a high boiling point and molar heat of vaporisation. AND • Explains why the intermolecular bonding in the non-polar compounds (dispersion forces) and the slightly polar substance (dipole-dipole forces) results in lower boiling points and molar heats of vaporisation	**3**
Any TWO of the above points	**2**
Provides some relevant information	**1**

Sample answer:

Water has polar molecules, strong hydrogen bonds between the molecules and weak intermolecular forces. A high amount of energy is needed to break the strong hydrogen bonds, resulting in water having a high boiling point and molar heat of vaporisation. Dichloromethane is slightly polar and has dipole-dipole forces holding the molecules together. Propane and tetrafluoromethane have non-polar molecules and weak dispersion forces. The weak intermolecular forces do not require a lot of energy to be broken, so these compounds have lower boiling points and lower molar heats of vaporisation.

Question 25 (4 marks)

"Sodium and chlorine are the two most reactive elements in Period 3 of the Periodic Table, but they are highly reactive for different reasons related to their unique atomic structure."

Explain this statement and outline the reasons for the reactivity of sodium and chlorine gas.

Marking Criteria	Marks
• Explains why sodium and chlorine readily form ions, correctly using first ionisation energy and electronegativity.	4
• Outlines how first ionisation energy and electronegativity result in the reactivity of Na and Cl.	3
• Outlines how first ionisation energy OR electronegativity results in the reactivity of Na OR Cl.	2
• Response contains some relevant information.	1

Sample answer:

Sodium is a Group I metal, and it has the lowest nuclear charge (11 protons) of a Period 3 element. Its single valence electron is shielded from the nuclear charge by two full inner shells. Thus, Na has a low first ionisation energy, meaning that its valence electron is easily removed. This makes Na very reactive and results in it forming a 1+ ion: $Na \rightarrow Na^{+} + e^{-}$. Chlorine on the other hand, while still having two full inner shells shielding the valence shell from the nucleus, has 17 protons in its nucleus. Thus, its effective nuclear charge is much higher than that of Na, and Cl has a high electronegativity as a result (attraction for an electron). As a result, chlorine is also highly reactive, forming a 1- ion to fill its valence shell: $Cl + e^{-} \rightarrow Cl^{-}$.

Note: Merely stating that Na 'only needs to lose one electron to achieve a full outer shell' and the Cl 'only needs to gain one electron' was only sufficient to gain one mark.

Question 26 (3 marks)

A bottle of oven-cleaning solution contains sodium hydroxide. The volume of the bottle is 1.50 L and the concentration of sodium hydroxide in the solution is 2.65 mol L^{-1}.

(a) Calculate the mass of sodium hydroxide in the bottle. (2 marks)

• Calculates the amount of NaOH in moles. AND • Calculates the mass of NaOH in grams	2
Provides some relevant calculations	1

Sample answer:

$$n(\text{NaOH}) = cV$$
$$= 2.65 \times 1.50$$
$$= 3.975 \text{ mol}$$
$$m(\text{NaOH}) = n \times MM$$
$$= 3.975 \times 39.998$$
$$= 159 \text{ g}$$

(b) Some of the solution is used and the remaining volume of solution in the bottle is 0.50 L. Water is added to the bottle so that the volume of the solution returns to 1.50 L.

Calculate the molar concentration of sodium hydroxide in the dilute solution. (1 mark)

Calculates the concentration of NaOH after dilution	**1**

Sample answer:

$$c_1V_1 = c_2V_2$$
$$c_2 = \frac{c_1V_1}{V_2}$$
$$= \frac{2.65 \times 0.5}{1.50}$$
$$= 0.9 \text{ mol L}^{-1}$$

Question 27 (3 marks)

Butane (C_4H_{10}) is one of the components of liquefied petroleum gas (LPG). It undergoes complete combustion in excess oxygen.

A sample of butane undergoes complete combustion in excess oxygen at 200°C and 182.4 kPa, producing 35.0 L of carbon dioxide.

Calculate the mass of butane reacted. Include a balanced chemical equation in your answer.

• Provides the correct balanced chemical equation. AND • Calculates the mass of butane reacted. AND • Uses correct unit conversions and the ideal gas law	3
Any TWO of the above points	2
Provides some relevant calculations	1

Sample answer:

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

$$PV = nRT$$

$$\begin{aligned} P &= 1.8 \text{ atm} \\ &= 1.8 \times 101.3 \\ &= 182.34 \text{ kPa} \end{aligned}$$

$$\begin{aligned} T &= 200°C \\ &= 200 + 273.15 \\ &= 473.15 \text{ K} \end{aligned}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$V = 35.0 \text{ L}$$

$$\begin{aligned} n(CO_2) &= \frac{PV}{RT} \\ &= \frac{182.34 \times 35.0}{8.314 \times 473.15} \\ &= 1.6223 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(C_4H_{10}) &= n(CO_2) \times \frac{2}{8} \\ &= 1.6223 \times \frac{2}{8} \\ &= 0.4056 \text{ mol} \end{aligned}$$

$$MM(C_4H_{10}) = 58.12 \text{ g mol}^{-1}$$

$$\begin{aligned} m(C_4H_{10}) &= n \times MM \\ &= 0.4056 \times 58.12 \\ &= 24 \text{ g} \end{aligned}$$

Question 28 (5 marks)

13.00 g of hydrogen gas is reacted with 11.68 g of solid iodine I_2 to produce hydrogen iodide gas.

(a) Identify the limiting reagent and the excess reagent. (2 marks)

• Shows calculation of the moles of H_2 and I_2 AND Identifies the limiting reagent. AND • Identifies the excess reagent	2
Provides some relevant calculations	1

Sample answer:

$$H_2(g) + I_2(s) \rightarrow 2HI(g)$$

$$n(H_2) = \frac{m}{MM}$$
$$= \frac{13.0}{2.016}$$
$$= 6.45 \text{ mol}$$

$$n(I_2) = \frac{m}{MM}$$
$$= \frac{11.68}{253.8}$$
$$= 0.04602 \text{ mol}$$

Iodine is the limiting reagent and hydrogen is the excess reagent.

(b) Calculate the amount of moles that the excess reactant is in excess. (1 mark)

Calculates the correct amount of excess reagent	1

Sample answer:

$$n(\text{H}_2 \text{ in excess}) = 6.45 - 0.04602$$
$$= 6.40 \text{ mol}$$

(c) Calculate the mass of the hydrogen iodide gas produced. (2 marks)

• Calculates the amount of hydrogen iodide produced. AND Shows the molar ratio of I_2:HI • Calculates the mass of hydrogen iodide produced	2
Provides some relevant calculations	1

Sample answer:

I_2 : HI

1 : 2

$$n(\text{HI}) = 2 \times n(\text{I}_2)$$
$$= 2 \times 0.04602$$
$$= 0.09204 \text{ mol}$$
$$m(\text{HI}) = n \times MM$$
$$= 0.09204 \times 127.908$$
$$= 11.77 \text{ g}$$

Question 29 (7 marks)

Ethylene glycol is a chemical used to depress the freezing point of water in products marketed as 'antifreeze'. It is a compound composed of C, H and O only.

A 44.80 g sample of this chemical was completely oxidized to form 61.6 g of carbon dioxide and 37.8 g of water.

(a) Calculate the mass of carbon and hydrogen in this sample. (4 marks)

Marking Criteria	Marks*
For each of C and H:	
• Calculates the mass which must be present in ethylene glycol	**2**
• Completes one correct step in the calculation.	**1**
*** 1 mark deducted from the total if either mass not calculated to 3 significant figues**	

Possible solution:
$n(CO_2)$ = m/MM = 61.6 / 44.01 = 1.39968.. mol
n(C) from compound = 1.39968.. mol
m(C) = nxMM = 1.39968.. x 12.01 = 16.8g (3sf)
$n(H_2O)$ = 37.8/ 18.016 = 2.09813.. mol
n(H) = 2.09813 x 2 = 4.19627.. mol
M(H) = 4.19627.. x 1.008 = 4.23g (3sf)

Alternative solution by calculating percentage composition

(b) Determine the mass of oxygen in antifreeze and hence the empirical formula of the compound.
(2 marks)

Marking Criteria	Marks
• Determines through calculation the empirical formula of ethylene gylycol.	**2**
• As above with one error or omission.	**1**

m(O) in compound = 44.80 – (mass of C and H) = 23.8g

n(O) = m/MM = 23.8 / 16 = 1.49 mol

C	H	O
n=1.40	n=2.1	n=1.5
Simplest ratio: 1.4/1.4 = 1	Simplest ratio: 2.1/1.4 =1.5	Simplest ratio: 1.5/1.4=1

Hence empirical formula = CH_3O

(c) If the molar mass of the compound is approximately 62 g mol^{-1}, determine the molecular formula of antifreeze. (1 mark)

Marking Criteria	Marks
• Determines the molecular formula of ethylene glycol	**1**

Number of 'empirical units' in a molecule = 62 / 31 = 2

Hence molecular formula is $C_2H_6O_2$

Question 30 (7 marks)

A group of students were investigating the use of different metals and their solutions in galvanic cells. They were provided with strips of magnesium, lead and silver and solutions of magnesium nitrate, lead nitrate and silver nitrate. All the solutions had 1.0 mol L^{-1} concentration.

(a) Which combination of metals has the highest potential difference? (1 mark)

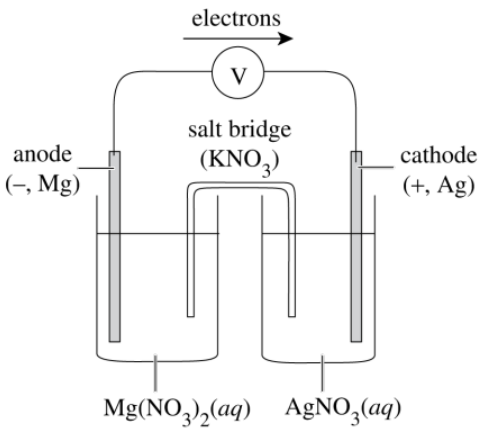
Identifies that magnesium and silver have the highest potential difference	1

Sample answer: Magnesium and silver

(b) Draw a diagram of a galvanic cell that uses the metals identified in part (a) and write a balanced chemical equation for the net ionic reaction that occurs in the cell. In your diagram, identify and label the electrodes, electrolytes and salt bridge, and label the electron flow. (5

Diagram	
• Draws a clear diagram. AND • Labels ALL of: − anode (with Mg) and cathode (with Ag) − electron flow from anode to cathode − electrolytes − salt bridge.	4
Draws a clear diagram. AND • Labels THREE of the above points.	3
Draws a clear diagram. AND • Labels TWO of the above points.	2
Provides some relevant information.	1
Net Ionic Reaction	
Provides the correct balanced chemical equation	1

Sample answer:



$$Mg(s) + 2Ag^{+}(aq) \rightarrow Mg^{2+}(aq) + 2Ag(s)$$

If the incorrect combination was chosen in (a), the diagram was assessed on the basis of that combination, to avoid carry-over error

(c) Calculate the cell potential of the galvanic cell. (1 mark)

• Calculates the cell potential	1

Sample answer:

cathode: Ag, $E° = 0.80$ V

anode: Mg, $E° = -2.36$ V

$$E°_{cell} = E°_{cathode} - E°_{anode}$$
$$= 0.80 - (-2.36)$$
$$= 3.16 \text{ V}$$

If the incorrect combination was chosen in (a), the cell potential was assessed on the basis of that combination, to avoid carry-over error

Question 31 (5 marks)

A catalyst can increase the rate of a chemical reaction.

Identify TWO other factors that can increase the rate of a reaction and explain, using collision theory, how these factors influence the rate of the reaction.

• Identifies TWO factors that can increase the rate of reaction. AND • Explains comprehensively, using the collision theory, how each factor influences the rate of reaction	**5**
Identifies TWO factors that can increase the rate of reaction. AND • Explains, using the collision theory, how each factor influences the rate of reaction	**4**
Identifies ONE factors that can increase the rate of reaction. AND • Explains comprehensively, using the collision theory, how each factor influences the rate of reaction	**3**
Identifies ONE factor that can increase the rate of reaction. AND • Explains, using the collision theory, how the factor influences the rate of reaction.	**2**
Provides some relevant information	**1**

Sample answer:

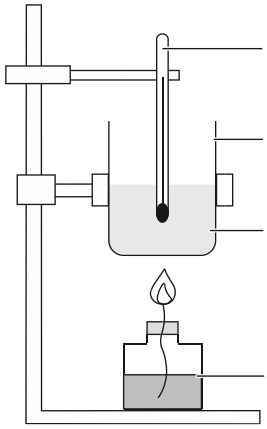
The four factors that can influence the rate of a reaction are the surface area of solid reactants, the concentration of reactants that are in solution, the pressure for gaseous reactants and the temperature. Increasing the surface area of a solid reactant increases the number of particles that can react with the other reactants. This increases the frequency of successful collisions, which increases the rate of reaction. Increasing the concentration of a reactant that is in solution increases the number of reactant particles in a given volume. This increases the frequency of successful collisions, which increases the rate of the reaction. Increasing the pressure for gaseous reactants increases the concentration of reactant particles. This increases the frequency of successful collisions, which increases the rate of reaction. Increasing the temperature increases the kinetic energy of reactant particles. This means more particles have sufficient energy to overcome the activation energy, which means the amount of successful collisions rises. Therefore, the rate of reaction increases.

Notes:

- For a comprehensive explanation of the effect of an increase in temperature, students must have referred to more particles having sufficient energy to overcome the activation energy of the reaction.
- Simply saying 'increase the number of reactant particles' was insufficient – students needed to say 'increase the concentration' (or words to that effect)

Question 32 (4 marks)

A student sets up the following experiment to determine the amount of energy that would be released by the combustion of a sample of hexane (C_6H_{14}).



The following data was recorded at the start of the experiment.

Mass of hexane burned	2.38 g
Mass of water heated	600 mL
Initial temperature of water	23.0°C

If the heat of combustion of hexane is –4163 kJ mol^{-1}, calculate the final temperature of the water.

• Calculates the amount of hexane in moles. AND • Calculates the energy released (q). AND • Calculates the change in the temperature of the water. AND • Calculates the final temperature of the water	**4**
Any THREE of the above points	**3**
Any TWO of the above points	**2**
Provides some relevant calculations	**1**

Sample answer:

$$n(\text{hexane}) = \frac{m}{MM}$$
$$= \frac{2.38}{86.172}$$
$$= 0.0276 \text{ mol}$$

$$\Delta H = \frac{q}{n}$$
$$q = \Delta H \times n$$
$$= 4163 \times 0.0276$$
$$= 114.9786 \text{ kJ}$$
$$= 114\,978.6474 \text{ J}$$
$$q = mc\Delta T$$
$$114\,978.6474 = 600 \times 4.18 \times$$
$$\Delta T = 45.8448°$$
$$\Delta T = T_2 - T_1$$
$$T_2 = \Delta T + T_1$$
$$= 45.8448 + 23.0$$
$$= 68.9°\text{C}$$

Question 33 (3 marks)

Potassium chloride is a water-soluble ionic salt. When 1.45 g of potassium chloride is dissolved in 50.0 mL of water, the temperature of the water decreases by 1.60°C.

Calculate the molar enthalpy of the reaction.

Calculates q AND Calculates the amount of solute in moles. AND • Calculates the molar enthalpy of the dissolution. AND • Provides the correct sign with correct units	**3**
Provides the above points with some errors. (Having an incorrect sign is a major error)	**2**
Provides some relevant calculations	**1**

Sample answer:

$$n(\text{KCl}) = \frac{m}{MM}$$
$$= \frac{1.45}{74.55}$$
$$= 0.0195 \text{ mol}$$
$$q = mc\Delta T$$
$$= 51.45 \times 4.18 \times 1.60$$
$$= 344.0976 \text{ J}$$
$$= 0.3441 \text{ kJ}$$
$$\Delta H_{\text{sol}} = \frac{q}{n}$$
$$= \frac{0.3441}{0.0195}$$
$$= +17.7 \text{ kJ mol}^{-1}$$