Student Number								

2022 **YEAR 11 EXAMINATION**

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 1.5 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used

Total Marks: 60

Section I – 10 marks (pages 1-3)

- Attempt questions 1–10
- Allow about 15 minutes for this part

Section II – 50 marks (pages 6 – 13)

- Attempt questions 11 - 19
- Allow about 1 hour and 15 minutes for this part

Section I
10 marks

Attempt Questions 1–10
Allow about 15 minutes for this part

Use the multiple-choice answer sheet for Question 1–10.

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1. The atomic number and mass number for 4 different nuclei are given below. Which two nuclei have the same number of neutrons?

	Atomic No.	***Mass No.***
I	101	258
II	102	258
III	102	260
IV	103	259

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

2. The oxidation number of Cl in $HClO_4$ is

A. +7
B. +5
C. +3
D. -1

3. The molecular compound XH_3 has three bonding pairs of electrons and one non-bonding pair of electrons around the central atom of X. What is the shape of XH_3?

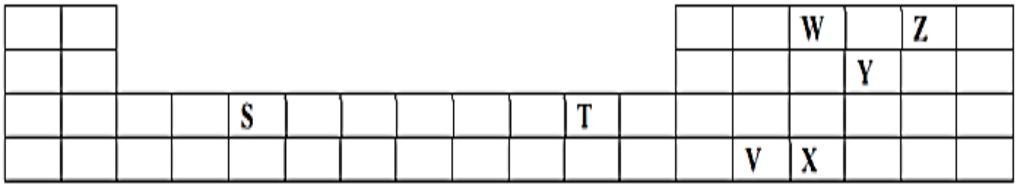
A. Linear
B. Pyramidal
C. Tetrahedral
D. Trigonal Planar

4. 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

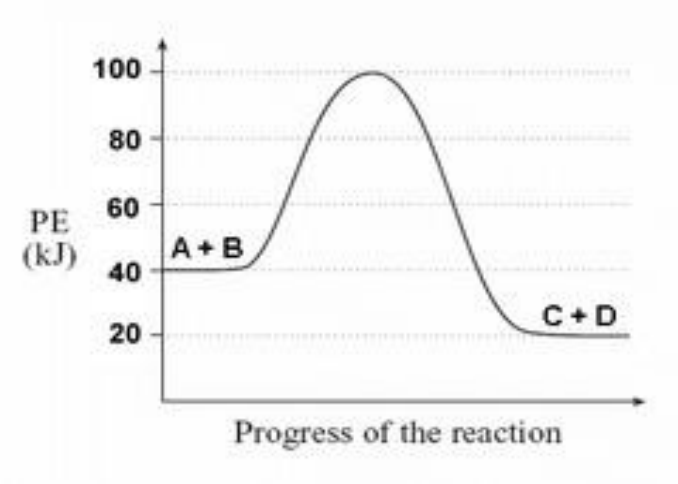
5. A sample of a compound of carbon and hydrogen contains 81.8% carbon by mass. The empirical formula of the compound would be
   A. C_3H_8
   B. C_2H_5
   C. C_2H_3
   D. CH_2

6. In the part of the Periodic Table shown below, certain elements are indicated by letters which are not the usual symbols for the elements concerned.



   Which one of the following sets of elements all exist as molecules at 25°C and atmospheric pressure?
   A. S, W and Z
   B. S, X and Y
   C. T, X and Y
   D. W, Y and Z

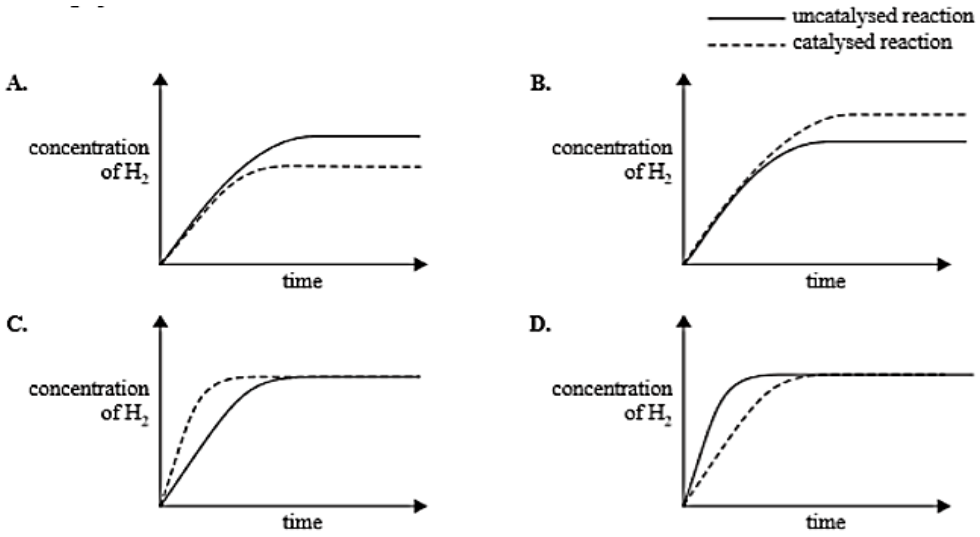
7. The energy diagram below shows the changes in energy (in kJ) during a chemical reaction.



   Which of the following lists correct information about this reaction?

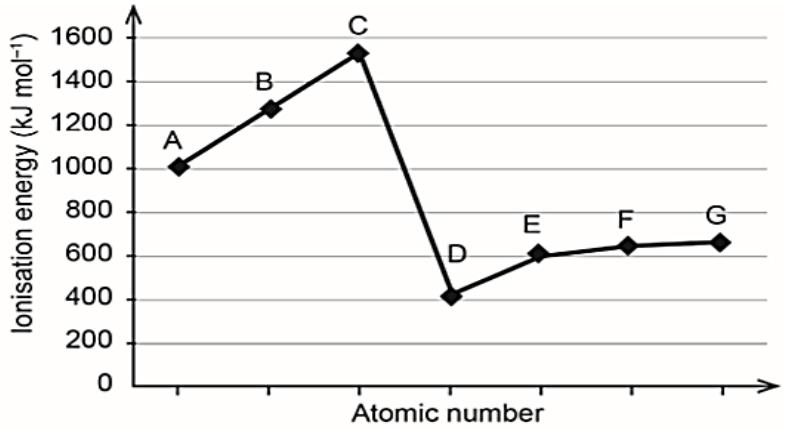
	Overall reaction	***Activation energy***	***Enthalpy change***
A.	Exothermic	+60 kJ	–80 kJ
B.	Exothermic	+60 kJ	–20 kJ
C.	Endothermic	+60 kJ	+20 kJ
D.	Endothermic	+100 kJ	+80 kJ

8. 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.



9. A 2 L sample of a gaseous hydrocarbon is burnt in excess oxygen. The only products of the reaction are 8 L of $CO_2(g)$ and 10 L of $H_2O(g)$, all at 100ºC and 1 atm pressure. The formula of the hydrocarbon is
   A. CH
   B. C_2H_4
   C. C_4H_{10}
   D. C_8H_{18}

10. The first ionisation energies of consecutive elements (labelled A to G) of the Periodic Table are shown below.



Which of the following would be the most likely formula of a compound formed between 2 of the elements represented in the plot?

A. BC
B. A_2B
C. EB_2
D. A_2D

End of Section I

Student Number								

Instructions for answering questions in Section I

- Complete your answers in either blue or black pen
- Multiple choice

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ **B** ○ **C** ● **D** ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ○ **B** ○ **C** ⊗ **D** ●

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ***correct*** and drawing an arrow as follows.

A ○ **B** ○ **C** ⊗ **D** ⊗

correct

Chemistry Section I – Multiple Choice Answer Sheet

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○

Student Number								
Section I / 10								
Section II / 50								
Total / 60								

Chemistry
Section II

50 marks
Attempt Questions 11-19
Allow about 1 hours 15 minutes for this section

Instructions

- Write your student number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.
- Show all relevant working in questions involving calculations
- Extra writing paper is available, please raise your hand to request more paper. If you use extra paper, clearly indicate your student number and which question you are answering.

Please turn over

Question 11 (2 marks)

Different isotopes of an element contain the same number of protons but have different atomic masses.

Complete the table. Use spdf notation.

Isotopes	Number of protons	Number of neutrons	Electron configuration
$^{13}_{6}C$			
$^{40}_{20}Ca$			

Question 12 (6 marks)

a) Sulfur has many isotopes. The most common are ^{32}S (95.02%), ^{33}S (0.75%) and ^{34}S (4.21%). Determine the atomic weight of sulfur based on these 3 isotopes. Show your working. (1 mark)

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b) Sulfur-37 is a radioactive isotope, with a half-life of 5 minutes. It decays to emit beta radiation. Write a balanced nuclear equation for the beta decay process. (1 mark)

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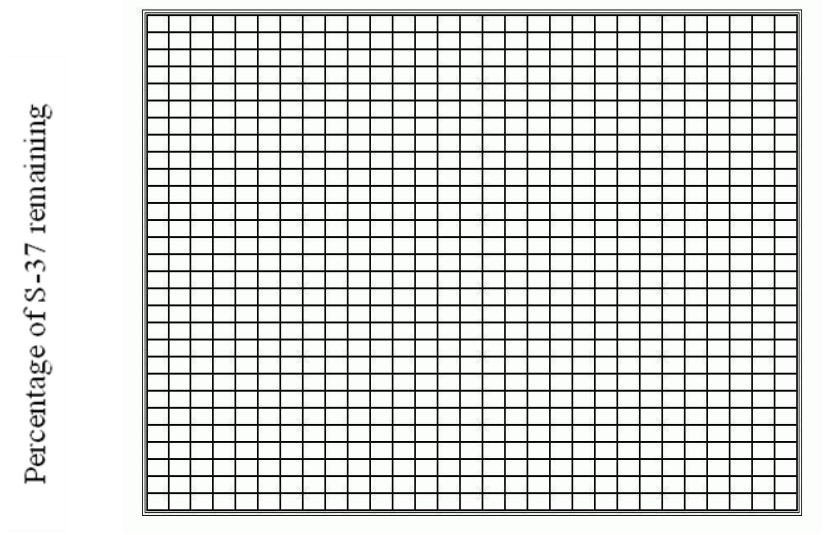
c) Sketch a graph to show the decay of sufur-37. Insert a suitable scale on each axis. (2 marks)



d) Sulfur exists as different allotropes. Define the term allotrope and suggest why different allotropes have different physical properties. (2 marks)

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Question 13 (4 marks)

Anhydrous sodium hydrogen carbonate ($NaHCO_3$) is used as a primary standard to make a standard solution.

Outline a method that can be used to prepare 250 mL of 0.1 M standard solution of $NaHCO_3$ in a school laboratory. In your answer, refer to the glassware and equipment required in each step.

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Question 14 (11 marks)

Consider the species listed below.
I – Na_2CO_3
II – SiO_2
III – NH_3
IV – Cu
V – CO_2
VI – CH_4

a) Complete the table below for each of the species above. (3 marks)

	Name	***Element or compound***	***Type of structure (molecule, ionic lattice, covalent network, metallic lattice)***
I			
II			
III			
IV			
V			
VI			

b) Identify which one of the above substances conducts electricity ONLY in the molten state. Explain your reasoning. (2 marks)

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c) Complete each cell of the table below for the two substances listed in the first column. (3 marks)

Substance	Lewis Dot diagram	Shape of the molecule	Polar/Non-polar
III			
V			

d) The boiling points of substances III and V are -33.34°C and -78.46°C, respectively. Explain the difference in these boiling points. (3 marks)

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Question 15 (3 marks)

The concentration of a solution of ammonia (NH_3) is 2.50% (w/v). What is the molar concentration produced by diluting 25.0 mL of this solution with 250.00 mL of water?

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Question 16 (6 marks)

a) When a piece of magnesium ribbon is placed into a solution of copper (II) nitrate, a reaction occurs. Write a balanced equation for the reaction. (1 mark)

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b) Write 2 half-equations for the oxidation and reduction reactions which have occurred in the reaction in part (a) above. Include the E° values for each half-equation. (2 marks)

Oxidation: …….....

Reduction: …….....

c) Draw a galvanic cell in the space provided which uses these reactions to produce an electric current. Label the anode and cathode, suitable electrolytes in each half-cell, the salt bridge and the direction of movement of ions present in the salt bridge. Indicate the direction of electron flow in the external circuit. Predict the overall voltage that can be achieved under standard conditions. (3 marks)

Question 17 (8 marks)

In an experiment, 50.0 mL of 0.400 M lead nitrate was added to 50.0 mL of 0.760 M potassium iodide in a calorimeter encased in a polystyrene insulating jacket. The mixture was stirred continuously, and the temperature rose from 18.4°C to 20.5°C as the following reaction occurred:

$$Pb(NO_3)_2\,(aq) + 2KI\,(aq) \rightarrow PbI_2\,(s) + 2KNO_3\,(aq) \qquad \Delta H = -49.0 \text{ kJ mol}^{-1}$$

a) Calculate the amount, in moles, of lead nitrate added. (1 mark)

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b) Calculate the amount, in moles, of potassium iodide used. (1 mark)

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c) Determine the number of moles of lead iodide formed. (2 marks)

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d) Calculate the energy released, in Joules, by the reaction in the calorimeter. Assume the specific heat capacity of the solution is 4.18 J g^{-1} K^{-1}. (1 mark)

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e) Use the experimental results to determine the value of the enthalpy change for the precipitation of 1.0 mol of lead iodide. (2 marks)

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f) Explain why the value of the enthalpy change calculated in part (d) varies from that given in the equation on the previous page. (1 mark)

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Question 18 (5 marks)

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

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Question 19 (5 marks)

The conversion of sulfur dioxide to sulfuric acid is used in a number of analytical techniques. A half-equation for this reaction is:

$$SO_2\,(aq) + 2H_2O\,(l) \rightarrow SO_4^{2-}\,(aq) + 4H^+\,(aq) + 2e^-$$

a) What is the name of this type of reaction? (1 mark)

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b) Sulfur dioxide is often used as a preservative in food and drink.
The sulfur dioxide content in dried apricots was determined by gravimetric analysis as follows:

- The dried apricots were powdered in a blender.
- A sample of the apricot powder weighing 50.00 g was put into a conical flask containing 100 mL of deionised water.
- A 3% solution of hydrogen peroxide was added to convert the dissolved sulfur dioxide to sulfate ions.
- An excess of barium chloride solution was then added. The barium sulfate precipitate was filtered off, dried and weighed to constant mass.

The following results were recorded:

mass of dry filter paper	0.864 g
mass of dry filter paper and $BaSO_4$ sample	1.338 g

Determine the percentage, by mass, of SO_2 in the apricot sample. (3 marks)

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c) Express the concentration of sulfur dioxide in the apricot sample in ppm. (1 mark)

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End of Paper

Extra Writing Space

Extra Writing Space

Extra Writing Space

Student Number								

2022 **YEAR 11 EXAMINATION**

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 1.5 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used

Total Marks: 60

Section I – 10 marks (pages 1 – 6)

- Attempt questions 1–10
- Allow about 15 minutes for this part

Section II – 50 marks (pages 7 – 17)

- Attempt questions 16 – 30
- Allow about 1 hour and 15 minutes for this part

Section I
10 marks

Attempt Questions 1–10
Allow about 15 minutes for this part

Use the multiple-choice answer sheet for Question 1–10.

---

1. The atomic number and mass number for 4 different nuclei are given below. Which two nuclei have the same number of neutrons?

	Atomic No.	*Mass No.*
I	101	258
II	102	258
III	102	260
IV	103	259

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

D
I has 101 P and 157 N.
II has 102 P and 156 N.
III has 102 P and 158 N.
IV has 103 P and 156 N.
Hence both II and IV (alternative D) have 156 N.

2. The oxidation number of Cl in $HClO_4$ is

A. +7
B. +5
C. +3
D. -1

3. The molecular compound XH_3 has three bonding pairs of electrons and one non-bonding pair of electrons around the central atom of X.

What is the shape of XH_3?

A. Linear
B. Pyramidal
C. Tetrahedral
D. Trigonal Planar

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

A. 5.0 g of H2
B. 20 g of O2
C. 50 g of NO2
D. 64 g of SO2

D is correct. 1 mol of a gas will occupy 22.71 L at 100 kPa and 0°C (273.15 K). 64 g of SO_2 gives:

$$n(SO_2) = \frac{m}{MM}$$
$$= \frac{64}{64.07}$$
$$= 1.0 \text{ mol}$$

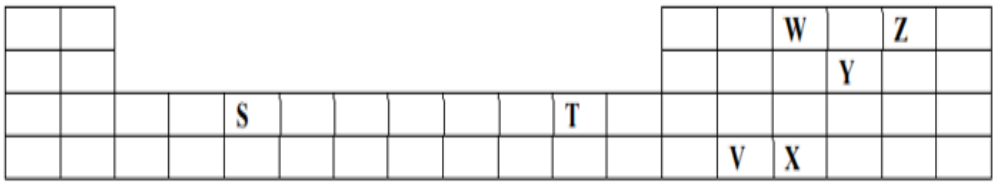
$$n = \frac{V}{Vn}$$
$$V = n \times Vn$$
$$= 1.0 \times 22.71 \text{ L}$$
$$= 22.71 \text{ L}$$

A, **B** and **C** are incorrect. The masses shown in each option do not equal 1 mol of the gas. 5.0 g of H_2 is 2.5 mol. 20 g of O_2 is 0.63 mol. 50 g of NO_2 is 1.1 mol. ??

5. A sample of a compound of carbon and hydrogen contains 81.8% carbon by mass. The empirical formula of the compound would be
   A. C_3H_8
   B. C_2H_5
   C. C_2H_3
   D. CH_2

   Mass ratio C:H = 81.8 : 18.2
   Mole ratio C:H = 81.8/12 : 18.2/1 = 6.8 : 18.2 = 1 : 2.67 = 3 : 8
   Hence empirical formula = C_3H_8

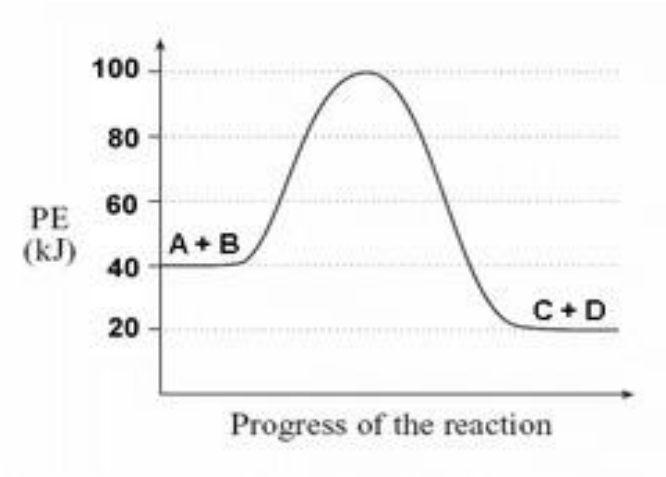
6. In the part of the Periodic Table shown below, certain elements are indicated by letters which are not the usual symbols for the elements concerned.



   Which one of the following sets of elements all exist as molecules at 25°C and atmospheric pressure?
   A. S, W and Z
   B. S, X and Y
   C. T, X and Y
   D. W, Y and Z

D
W, Y and Z are all non-metals in Groups 5, 6 and 7. Only non-metals can form molecules. X is a metalloid; V, S and T are metals.

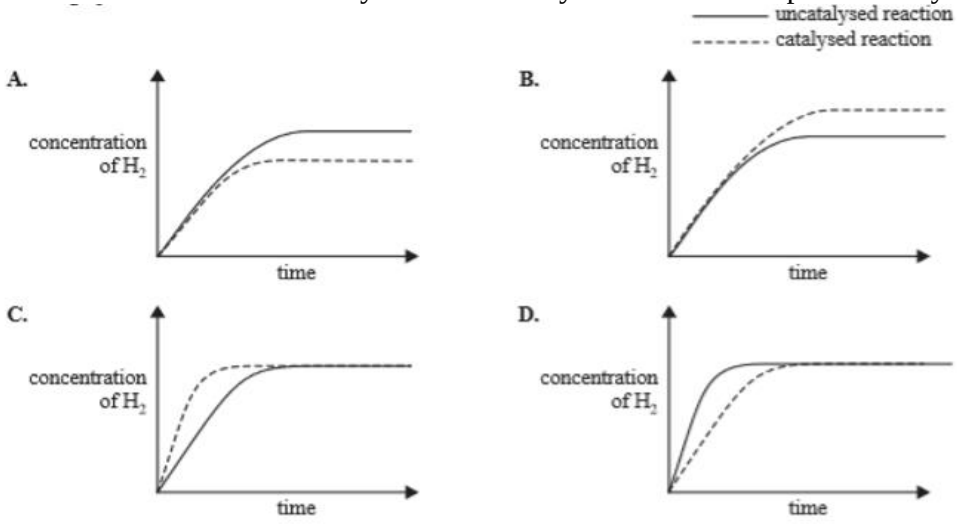
7. The energy diagram below shows the changes in energy (in kJ) during a chemical reaction.



Which of the following lists correct information about this reaction?

	Overall reaction	***Activation energy***	***Enthalpy change***
A.	Exothermic	+60 kJ	–80 kJ
B.	Exothermic	+60 kJ	–20 kJ
C.	Endothermic	+60 kJ	+20 kJ
D.	Endothermic	+100 kJ	+80 kJ

8. 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.



C

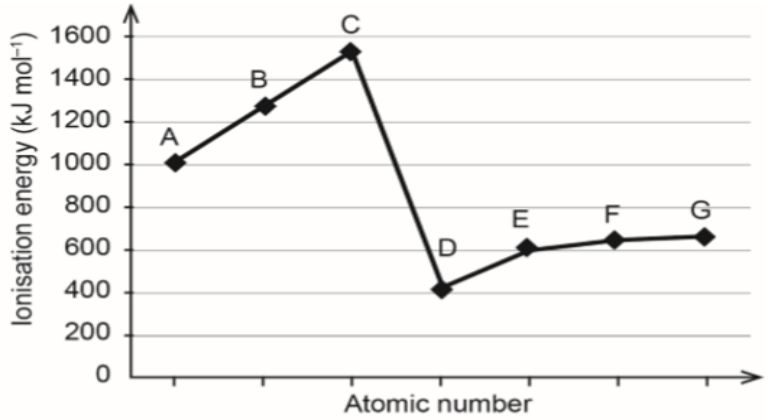
The catalysed reaction occurs at a faster rate (steeper graph) but does not change the total concentration of the product.

9. A 2 L sample of a gaseous hydrocarbon is burnt in excess oxygen. The only products of the reaction are 8 L of $CO_2(g)$ and 10 L of $H_2O(g)$, all at 100ºC and 1 atm pressure. The formula of the hydrocarbon is
   A. CH
   B. C_2H_4
   C. C_4H_{10}
   D. C_8H_{18}

   C

   Using Avogadro's Law, at the same temperature and pressure, the volume of gases is proportional to the no. of moles present.
   Hence $2C_xH_y + zO_2 \rightarrow 8CO_2 + 10H_2O$
   $C_xH_y + ½zO_2 \rightarrow 4CO_2 + 5H_2O$
   Hence x = 4 and y = 10

10. The first ionisation energy of consecutive elements (labelled A to G) of the Periodic Table is shown below.



   Which of the following would be the most likely formula of a compound formed between 2 of the elements represented in the plot?

   A. BC
   B. A_2B
   C. EB_2
   D. A_2D

C

Elements are
A = Group 6, B = Group 7, C = Noble gas (so no compounds), D = Group 1, E = Group 2,
F = Group 3, G = Group 4
The only correct combination is C (EB_2) – a Group 2 metal combining with a halogen. An example would be $MgCl_2$. A compound of Group 6 and Group 7 would be AB_2 (not A_2B) (e.g. OCl_2). A compound of Group 6 and Group 1 would be D_2A (not A_2D) (e.g. Na_2O).

End of Section I

2022 **YEAR 11 EXAMINATION**

Student Number								

Instructions for answering questions in Section I

- Complete your answers in either blue or black pen
- Multiple choice

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ **B** ○ **C** ● **D** ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ○ **B** ○ **C** ⊗ **D** ●

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ***correct*** and drawing an arrow as follows.

Chemistry Section I – Multiple Choice Answer Sheet

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○

Student Number								
Section I / 10								
Section II / 50								
Total /60								

Chemistry
Section II

50 marks
Attempt Questions 11-19
Allow about 1 hours 15 minutes for this section

Instructions

- Write your student number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.
- Show all relevant working in questions involving calculations
- Extra writing paper is available, please raise your hand to request more paper. If you use extra paper, clearly indicate your student number and which question you are answering.

Please turn over

Question 11 (2 marks)

Different isotopes of an element contain the same number of protons but have different atomic masses.

Complete the table. Use spdf notation.

Criteria	Mark
• Correctly identifies the number of neutrons and protons • Provides correct spdf configuration for Carbon • Provides correct spdf configuration for Calcium including the last two electrons in the 4s subshell rather than 3d	2
• Some error	1

Sample answer

Isotopes	Number of protons	Number of neutrons	Electron configuration
$^{13}_{6}C$	6	7	$1s^2\ 2s^2\ 2p^2$
$^{40}_{20}Ca$	20	20	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

Question 12 (6 marks)

a) Sulfur has many isotopes. The most common are ^{32}S (95.02%), ^{33}S (0.75%) and ^{34}S (4.21%). Determine the atomic weight of sulfur based on these 3 isotopes. Show your working. (1 mark)

19 (a) (1 mark)

Criteria	Mark
• Correctly determines the atomic weight	1

Sample answer

Atomic weight = 32(95.02/100) + 33(0.75/100) + 34(4.21/100) = 32.085 = 32.09

b) Sulfur-37 is a radioactive isotope, with a half-life of 5 minutes. It decays to emit beta radiation. Write a balanced nuclear equation for the beta decay process. (1 mark)

12 (b) (1 mark)

Criteria	Mark
• Writes a correct, balanced nuclear equation	1

Sample answer

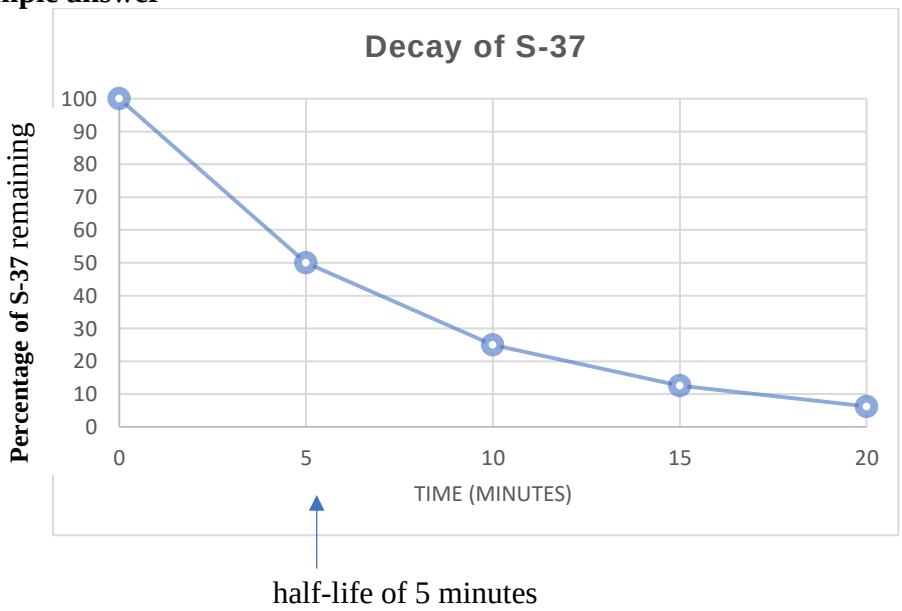
$^{37}_{16}S \rightarrow {}^{0}_{-1}e + {}^{37}_{17}Cl$

c) Sketch a graph to show the decay of sufur-37. Insert a suitable scale on each axis. (2marks)

12 (c) (2 marks)

Criteria	Marks
• Draws a graph with title, labelled axes and correct shape with half-life of 5 minutes	2
• Draws a partially correct graph	1

Sample answer



d) Sulfur exists as different allotropes. Define the term allotrope and suggest why different allotropes have different physical properties. (2 marks)

12 (d) (2 marks)

Criteria	Marks
• Describes different structures of the element sulfur • Explains why the allotropes of sulphur have different physical properties • Explains why the allotropes of sulphur have similar chemical properties	2
• ONE of the above missing	1

Sample answer

The most commonly encountered form of sulfur (also known as α-sulfur) is an orthorhombic form with structure S_8, which adopts a puckered ring – or "crown" – structure in the solid state. In addition to S_8, sulfur rings of 6, 7, 9–15, 18 and 20 atoms are known.
β-sulfur is a yellow solid with a monoclinic crystal form and is less dense than α-sulfur. Like the α-form it contains puckered S_8 rings and only differs from it in the way the rings are packed in the crystal.

A third allotrope is γ-sulfur. It crystallises in pale yellow monoclinic needles. It contains puckered S_8 rings like α-sulfur and β-sulfur and only differs from them in the way that these rings are packed.
Amorphous sulfur is formed as molten sulfur cools to a plastic non-crystalline form. These allotropes have different structures, with different physical properties, because of the different ways the sulfur atoms are covalently bonded together or the different ways the rings form solid crystals.
The different forms have different physical properties such as density and melting points because of the different forces between neighbouring rings.
However, the atoms in each of these forms are the same. So, the chemical properties, which involve sulfur atoms forming compounds, are the same for the different allotropes.

Question 13 (4 marks)

Anhydrous sodium hydrogen carbonate ($NaHCO_3$) is used as a primary standard to make a standard solution.

Outline a method that can be used to prepare a 250ml of 0.1M standard solution of $NaHCO_3$ in a school laboratory. In your answer, refer to the glassware and equipment required in each step.

Criteria	Marks
Accurately calculates the amount of $NaHCO_3$ required to make the solution. AND Describes all steps in the correct order for the preparation, including weighing, qualitative transfer, dissolving and filling up to the mark. AND Refers to suitable glassware and equipment	**4**
Accurately calculates the amount of $NaHCO_3$ required to make the solution. AND Describes all steps in the correct order with some errors. AND Refers to suitable glassware and equipment.	3
Calculates the amount of $NaHCO_3$ required to make the solution but not accurately AND Describes all steps in the correct order with some errors. AND Refers to suitable glassware OR equipment	2
Provides some relevant information	1

Sample Answer:

To prepare 250 ml of 0.1 M $NaHCO_3$:

$$n(\mathrm{NaHCO3}) = cV = 0.1 \times 0.250 = 0.025\ mol$$

$$As\ n = \frac{m}{MM}$$

$$m = n \times MM = 0.025 \times \left(22.99 + 1.008 + 12.011 + (15.999x3)\right) = 0.025 \times 84.006 = 2.10015g$$

Therefore, 2.1g of $NaHCO_3$ is required to make this standard solution.

Method:

1. 2.1 g of Pure anhydrous sodium hydrogen carbonate ($NaHCO_3$) is placed in a clean and dry beaker and accurately weighed on a balance.
2. The solid is transferred into a 250 ml volumetric flask using a clean and dry funnel.
3. The beaker is rinsed with distilled water, and the distilled water used is poured into the flask.
4. More distilled water is added to the flask until it is half-full. A stopper is placed in the flask, and the flask is swirled to dissolve the solid.
5. The flask is filled with distilled water until the bottom of the meniscus of the solution lines up with the relevant mark.
6. The flask is shaken to ensure the concentration of the solution is even.

Question 14 (11 marks)

Consider the species listed below.

I – Na_2CO_3
II – SiO_2
III – NH_3
IV – Cu
V – CO_2
VI – CH_4

a) Complete the table below for each of the species above. (3 marks)

14 (a) (3 marks)

Criteria	Marks
• Completes SIX lines of the table correctly	3
• Completes FIVE lines of the table correctly	2
• Completes FOUR lines of the table correctly	1

Sample answer

	Name	*Element or compound*	*Type of structure (molecule, ionic lattice, covalent network, metallic lattice)*
I	sodium carbonate	compound	ionic lattice
II	silicon dioxide	compound	covalent network
III	ammonia	compound	molecule
IV	copper	element	metallic lattice
V	carbon dioxide	compound	molecule
VI	methane	compound	molecule

b) Choose one of the above substances that would you expect to be a conductor of electricity ONLY in the molten state? Explain your reasoning. (2 marks)

14 (b) (2 marks)

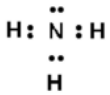
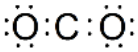
Criteria	Marks
• Identifies sodium carbonate as conductor in the molten state AND • Explains that conduction requires movement of ions (in sodium carbonate)	2
• Identifies sodium carbonate OR • Explains that conduction requires movement of charges (in sodium carbonate)	1

Sample answer

Sodium carbonate.
Ionic solids, when molten, conduct electricity because of moving and transferring the charge between electrodes.

Criteria	Mark
• Correct 3 features for both the substances	3
• Some error for one of the features	2
• More than one error.	1

c) Complete each cell of the table below for the two substances listed in the first column. (3 marks)

Substance	Lewis Dot diagram	Shape of the molecule	Polar/Non-polar
III		Pyramidal	Polar
V		Linear	Non-polar

d) The boiling points of substances III and V are -33.34 °C and -78.46°C, respectively. Explain why the boiling point of substance III is substantially higher than that of substance V (3 marks)

Criteria	Mark
• Demonstrates a thorough understanding of the concept by relating cause and effect	3
• Demonstrates a basic understanding of the concept by relating cause and effect	2
• Some explanation provided but lacks cohesion.	1

Question 15 (3 marks)

The concentration of a solution of ammonia (NH_3) is 2.50% (w/v). What is the molar concentration produced by diluting 25.0mL of this solution with 250mL of water?

Criteria	Mark
• Accurately calculates the molar concentration • Shows all working out • Answer correct to 3 sf	3
• Accurately calculates the molar concentration • Shows all working out	2
• Some error	1

Sample Answer

Mass of NH_3 in 25mL of 2.5%

$$m_{(NH3)} = \frac{2.5}{100} \times 25 = 0.625g\ (in\ 25mL)$$

$$n_{(NH3)} = \frac{m}{MM} = \frac{0.625}{(14) + (1.008x3)} = 3.67 \times 10^{-2}\ mol.in\ 25mL$$

$$c = \frac{n}{V} = \frac{3.67 \times 10^{-2}}{0.250} = 0.147\ molL^{-1}$$

Marker's feedback:
Could have used $C_1V_1 = C_2V_2$ but had to convert the C_1 into molar concentration first to obtain the C_2 as a molar concentration.
Some students used $C_1V_1 = C_2V_2$, and calculated the C_2 in g/L

Question 16 (6 marks)

a) When a piece of magnesium ribbon is placed into a solution of copper (II) nitrate, a reaction occurs. Write a balanced equation for the reaction.

16 (a) (1 mark)

Criteria	Mark
• Writes a balanced equation for the reaction between magnesium and copper (II) nitrate solution	1

Sample answer

$Mg\ (s) + Cu(NO_3)_2\ (aq) \rightarrow Mg(NO_3)_2\ (aq) + Cu\ (s)$

b) Write 2 half-equations for the oxidation and reduction reactions which have occurred in the reaction in part (a) above. Include the E° values for each half-equation.

Oxidation: …….....

Reduction: …….....

16 (b) (2 marks)

Criteria	Marks
• Writes 2 correct half-equations and 2 correct E° values	2
• Writes 1 correct half-equation and 1 correct E° value	1

Sample answer

Oxidation: $Mg\ (s) \rightarrow Mg^{2+}\ (aq) + 2e^-$ +2.36 V

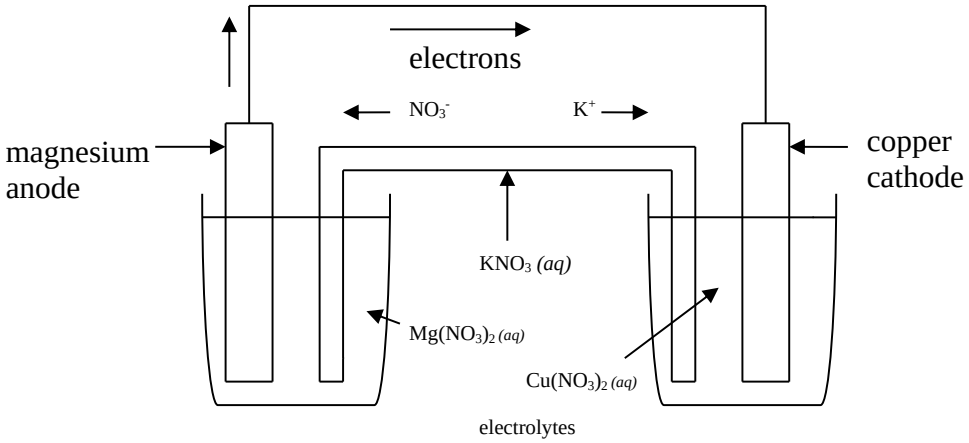
Reduction: $Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)$ +0.34 V

c) Draw a galvanic cell in the space provided which uses these reactions to produce an electric current. Label the anode and cathode, suitable electrolytes in each half-cell, the 6salt bridge and the direction of movement of ions present in the salt bridge. Indicate the direction of electron flow in the external circuit. Predict the overall voltage that can be achieved under standard conditions.

16 (c) (3 marks)

Criteria	Marks
• Draws an appropriate diagram of a galvanic cell labelling the anode, cathode, electrolytes, direction of electron flow and direction of ion movement in the salt bridge AND predicts the correct voltage of the galvanic cell	3
• Draws a partially correct diagram of a galvanic cell showing some correct labelling AND predicts the correct voltage of the galvanic cell	2
• Draws a partially correct diagram of a galvanic cell showing some correct labelling OR predicts the correct voltage of the galvanic cell	1

Sample answer



Overall voltage = +2.36 + 0.34 = 2.70 V

Question 17 (8 marks) q 23 BH

In an experiment, 50.0 mL of 0.400 M lead nitrate was added to 50.0 mL of 0.760 M potassium iodide in a calorimeter encased in a polystyrene insulating jacket. The mixture was stirred continuously, and the temperature rose from 18.4°C to 20.5°C as the following reaction occurred:
$Pb(NO_3)_2\ (aq) + 2KI\ (aq) \rightarrow PbI_2\ (s) + 2KNO_3\ (aq)$ $\Delta H = -49.0$ kJ mol^{-1}

a) Calculate the amount, in moles, of lead nitrate added. (1 mark)

17 (a) (1 mark)

Criteria	Mark
• Correct answer	1

Sample answer

n (lead nitrate) = cV = 0.400 x 50/1000 = 0.0200 mol

b) Calculate the amount, in moles, of potassium iodide used. (1 mark)

17 (b) (1 mark)

Criteria	Mark
• Correct answer	1

Sample answer

n (potassium iodide) = cV = 0.760 x 50/1000 = 0.0380 mol

c) Determine the number of moles of lead iodide formed. (2 marks)

17 (c) (2 marks)

Criteria	Marks
• Correct answer showing calculation/reasoning to identify KI as limiting reactant	2
• Incorrect answer but correctly identifies KI as the limiting reactant	1

Sample answer

Since $Pb(NO_3)_2$ and KI react in a 1 : 2 ratio, 0.0200 mol $Pb(NO_3)_2$ would requires 0.0400 mol of KI for complete reaction. There are only 0.0380 mol KI, so KI is the limiting reactant and there is excess lead nitrate present.

n (PbI_2) = n (KI)/2 = 0.0380/2 = 0.0190 mol

d) Calculate the energy released, in Joules, by the reaction in the calorimeter. Assume the specific heat capacity of the solution is 4.18 J g^{-1} K^{-1}. (1 mark)

17 (d) (1 mark)

Criteria	Mark
• Correct answer	1

Sample answer

$\Delta H = mc\Delta T$ = 100 x 4.18 x 2.1 J = 877.8 J = 8.8 x 10^2 J

e) Determine the value of the enthalpy change for the precipitation of 1 mole of lead iodide, using your experimental results. (2 marks)

17 (e) (2 marks)

Criteria	Marks
• Correct answer	2
• Incorrect answer but correct reasoning	1

Sample answer

The precipitation of 0.0190 mol of PbI_2 releases 8.8 x 10^2 J of energy.
Hence the precipitation of 1.0 mol of PbI_2 would release 8.8 x 10^2 x 1.0 / 0.0190 = 46320 J

Hence ΔH = –46 kJ mol^{-1}

f) Explain why the value of the enthalpy change calculated in part (d) varies from that given in the equation on the previous page.? (1 mark)

17 (f) (1 mark)

Criteria	Mark
• Correct explanation in terms of heat loss to the surroundings or to the calorimeter itself	1

Sample answer

The answer based on the experimental data indicates less heat being released than that given in the equation. This would arise as some heat losses to the environment would occur as the precipitation occurs even though an insulating jacket was used. The calorimeter itself may absorb some heat, especially if it is made from metal. This amount of heat (or the calorimeter constant) have not been included in the given data. Also the temperature change is very small. Better results could have been achieved if the solutions had been more concentrated or the volume of reactants greater.

Question 18 (5 marks)

A catalyst can increase the rate of a chemical reaction.

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

Criteria	Marks
• Identifies THREE factors that can increase the rate of reaction. • Thoroughly explains, using the collision theory, how each factor influences the rate of reaction by relating cause and effect	5
• Identifies THREE factors that can increase the rate of reaction. • Explains, using the collision theory, how each factor influences the rate of reaction	4
• Identifies THREE factors that can increase the rate of reaction. Explanation lacks some key points and doesn't completely relate cause to effect	3
• Identifies TWO correct factors that can increase the rate of reaction. Explanation lacks some key points and doesn't completely relate cause to effect	2
• Some attempt made to explain one of the factors.	1

Sample Answer (any three factors)

The 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.

Marker's feedback:

This question was done well by most except a few who couldn't explain it well and did not relate cause to effect. Especially not mentioning the activation energy overcome by particles at a higher temperature.

Question 19 (6 marks)

The conversion of sulfur dioxide to sulfuric acid is used in a number of analytical techniques. A half-equation for this reaction is:

$$SO_2\,(aq) + 2H_2O\,(l) \rightarrow SO_4^{2-}\,(aq) + 4H^+\,(aq) + 2e^-$$

a) What type of reaction is this? (1 mark)

19 (a) (1 mark)

Criteria	Mark
• Identifies the half-reaction as an oxidation reaction	1

Sample answer

The reaction is classified as an oxidation reaction.

Marker's feedback:

Part a – many students lost the mark for saying that it is a redox reaction because it is not the complete overall equation, it's just the oxidation half equation.

b) Sulfur dioxide is often used as a preservative in food and drink.
The sulfur dioxide content in dried apricots was determined by gravimetric analysis as follows:

- The dried apricots were powdered in a blender.
- A sample of the apricot powder weighing 50.00 g was put into a conical flask containing 100 mL of de-ionised water.
- A 3% solution of hydrogen peroxide was added to convert the dissolved sulfur dioxide to sulfate ions.
- An excess of barium chloride solution was then added. The barium sulfate precipitate was filtered off, dried and weighed to constant mass.

The following results were recorded:

mass of dry filter paper	0.864 g
mass of dry filter paper and $BaSO_4$ sample	1.338 g

Determine the percentage, by mass, of SO_2 in the apricot sample. (3 marks)

19 (b) (3 marks)

Criteria	Marks
• Correct answer	3
• Correct moles of SO_4^{2-}	2
• Correct mass of $BaSO_4$	1

Sample answer

Mass of barium sulfate precipitate = 1.338 – 0.864 g = 0.474 g
Moles $BaSO_4$ = 0.474 / 233.37 = 0.002031 mol

$BaCl_2\,(aq) + SO_4^{2-}\,(aq) \rightarrow BaSO_4\,(s)$

Moles SO_4^{2-} = 0.002031
Hence from the equation provided, moles SO_2 in the solution = 0.002031 mol
Mass of SO_2 = 0.002031 x 64.07 g = 0.1301 g
% of SO_2 in 50 g apricot powder = 0.130/50.00 x 100 = 0.260% (to 3 s.f.)

Marker's feedback:
Part b : Many students did this calculation correctly. Some students used the molar mass of sulfate ions instead of sulfur dioxide to do the final step of the calculation, which is incorrect. Hence they lost a mark. Question was asking for the concentration of sulfur dioxide not the sulfate ions!

c) Express the concentration of sulfur dioxide in the apricot sample in ppm. (1 mark)

19 (c) (1 mark)

Criteria	Mark
• Correct answer	1

Sample answer

The concentration of 0.260% (g per 10^2 g) is the same as 2.60 x 10^3 ppm (g per 10^6 g).

Marker's feedback:
Part c: Please review the different types of ways to express concentration if you got this wrong.

End of Paper

Mapping Grid

Question number	Marks	Module/content
1	1	1.2.1 – Atomic structure and atomic mass
2	1	3.2.4 – Oxidation numbers
3	1	1.4.2 – Shapes of molecules
4	1	2.2.3 – Mole Concept (n=m/MM)
5	1	2.2.3 – Mole concept (%age composition and Empirical formula)
6	1	1.3.1 – Periodicity (state of matter at RT)
7	1	4.1.3 – Energy profile diagram
8	1	4.1.4 – Role of catalysts in reactions
9	1	2.2 and 2.4.1 – Mole and Gas laws
10	1	1.3.1 – Periodicity (Ionisation energy)
11	2	1.2.2 – spdf notation
12 a	1	1.2.3 – Relative atomic mass of Isotopes

12 b and c	3	1.2.5 – Radioactivity using half life
12 d	2	1.4.3 - Allotropes
13	4	2.3.3 – Making Standard solution and performing dilutions
14 a	3	1.4.4 – Chemical structure, Bonding
14 b, c and e	7	1.4.5 – Intermolecular forces to explain physical properties
14 d	2	1.4.2 – Polarity
15	3	2.3.1 – Measuring concentrations
16	6	3.2.6 – Galvanic cell and redox reactions
17 a, b, c	4	2.2.3 – Mole concept
17 d, e, f	4	4.1.2 – q = mcT
18	5	3.3 Rates of reaction
19 a and d	2	3.1 – Chemical Reactions
19 b and c	4	2.1.2 – Chemical Reactions and stoichiometry