2021

JAMES RUSE AGRICULTURAL HIGH SCHOOL

YEAR 11 THEORY EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 1.5 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formula sheet, data sheet and Periodic Table are provided.

Total Marks – 70

Section I – 30 marks (pages 2 – 13)

- Attempt questions 1 – 30
- Allow about 40 minutes for this section

Section II – 40 marks (pages 14 – 17)

- Attempt questions 31 – 37
- Allow about 50 minutes for this section

Section I

30 marks
Attempt Questions 1 – 30
Allow about 40 minutes for this section
Indicate your answers on the multiple choice grid in the google form provided.

1 A Chemist accidentally synthesised a new element which they named Natrium. They performed a series of tests to examine the physical properties of this element and recorded the observations listed in the table provided:

Temperature (◦C)	0	25	80
Pressure (kPa)	100	100	100
State	Solid	Liquid	Gas

What is the correct classification for Natrium at standard laboratory conditions*?*

A. Gas
B. Aqueous
C. Solid
D. Liquid

2 What is the standard used to compare the relative masses of atoms and molecules?

A. Hydrogen – 1
B. Carbon – 12
C. Nitrogen – 14
D. Oxygen – 164

3 What effect does a catalyst have on a reaction?

A. It changes the ΔH of the reaction.

B. It increases the kinetic energy of the reactants.

C. It decreases the potential energy of the products.

D. It provides a reaction mechanism with a lower activation energy.

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A. 0.180 mol L^{-1}

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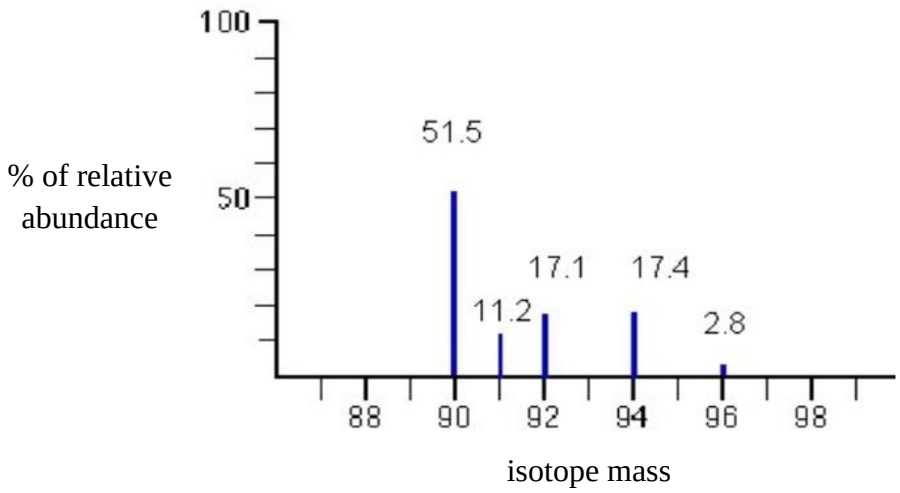

What is the relative atomic mass of X?

A. 90.8

B. 91.3

C. 89.7

D. 88.0

6 The electronegativity values for a series of elements are listed below.

Element	*Electronegativity*
H	2.1
C	2.5
N	3.0
F	4.0

Which of the following covalent bonds is the most polar?

A. H—F

B. H—H

C. H—C

D. H—N

7 The relative molecular mass of butane is 58.

Which statement best describes what this means?

A. each molecule of butane weighs 58 g.

B. each molecule of butane is 29 times as heavy as the hydrogen atom.

C. 6.022×10^{23} molecules of butane will have a mass of 58 g.

D. one mole of butane occupies a volume of 58 L at 298 K and 100 kPa

8 Which of the following represents the greatest number of particles?

A. 6×10^{23} electrons

B. 1.5 g hydrogen gas

C. 49.0 mL oxygen gas at 298 K and 100 kPa

D. 200 mL of a 2.0 mol L^{-1} solution of NaCl

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$$CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$$

What mass of calcium oxide is produced from the decomposition of 25 g $CaCO_3\ (s)$?

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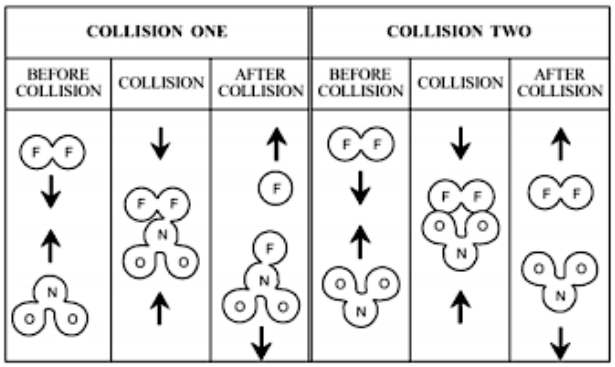

Which one of the following factors accounts for the success of collision one and not collision two?

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A. There are always as many molecules before the reaction as after the reaction.

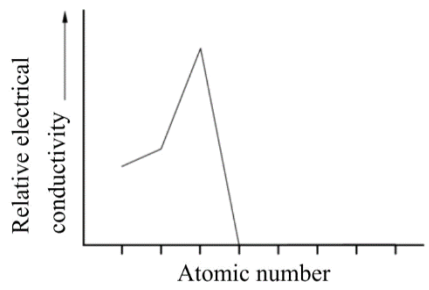
B. The total number of moles is always the same.

C. The total mass is always the same.

D. The amount of energy in the products and reactants is always the same.

14 Which of the following graphs is a correct representation of the relative electrical conductivities of elements across the third period of the periodic table.

A.



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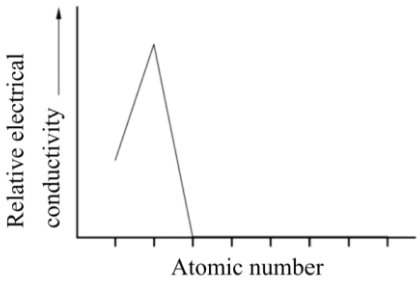

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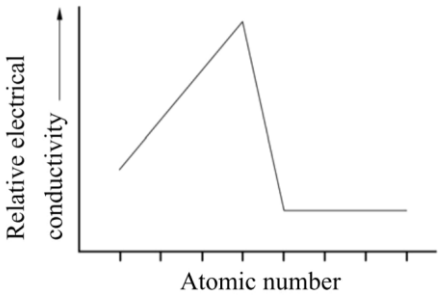

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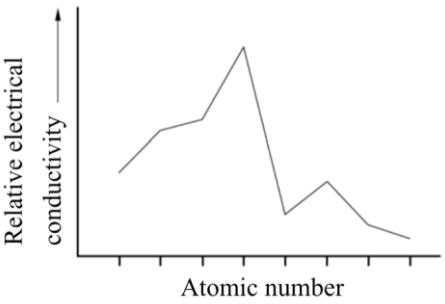


15 Why do dust particles suspended in the air inside unheated grain silos sometimes react explosively?

A. They have high kinetic energy.

B. There is a catalytic effect on the dust.

C. There is a large surface area for the reaction.

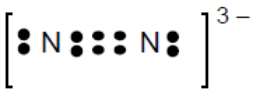
D. The reaction has high activation energy.

16 At a high temperature calcium will react with nitrogen to form Calcium nitride

$$3Ca\ (s)\ +\ N_2\ (g)\ \rightarrow\ Ca_3N_2\ (s)$$

Which of the following Lewis electron dot structures is the correct representation of the nitride ion present?

A.



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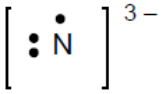

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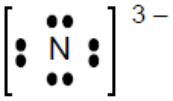

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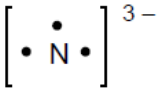


17 100,000 t of copper ore contains 4.5% w/w of chalcopyrite, $CuFeS_2$.

What is the mass of chalcopyrite?

A. 4,500 kg

B. 4.5×10^6 kg

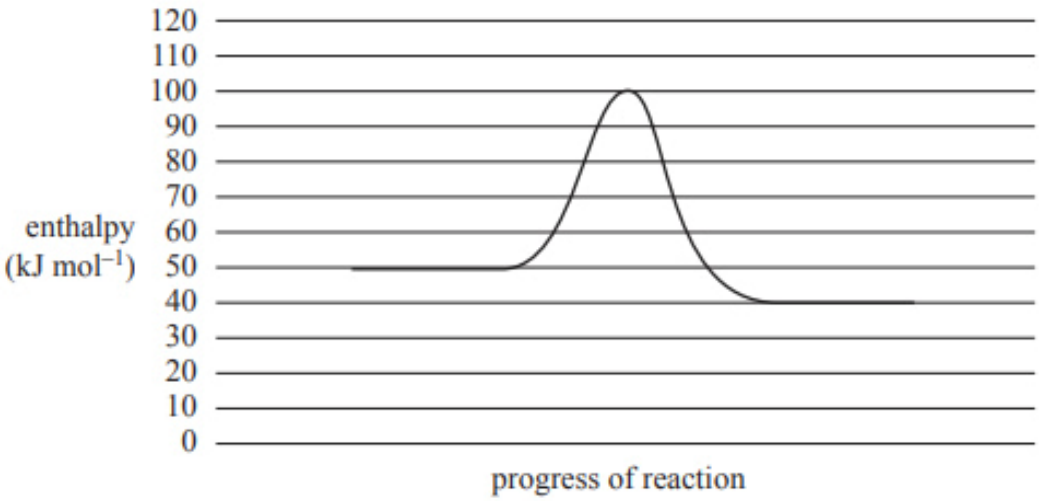
C. 4.5×10^9 kg

D. 4.5×10^4 kg

18 Which of the following alternatives gives the correct electron configuration for the excited state for the corresponding element?

	Atomic number	*Electron configuration*
A.	5	$1s^2 2s^2$
B.	6	$1s^2 2s^2 2p^2$
C.	8	$1s^2 2s^2 2p^3 3s^1$
D.	9	$1s^2 2s^2 2p^6$

19 An energy profile diagram is shown below.



Which of the following represents the energy profile of the reverse reaction?

	Final product energy (kJ mol^{-1})	*ΔH (kJ mol^{-1})*
A.	40	+10
B.	50	+10
C.	50	–10
D.	40	–10

20 Iodine is a solid at standard room temperature and pressure.

Which of the following statements concerning the structure of iodine is correct?

I Iodine has a giant covalent structure.

II Iodine molecules are held together by dispersion forces.

III Iodine atoms are held together in pairs by covalent bonds.

A. I only

B. II only

C. both I and III

D. both II and III

21 Which two processes are commonly used by Torres Strait Islanders and Aboriginal people to detoxify fruits?

A. Roasting and neutralising with acids

B. Filtering and dissolving

C. Heating and dissolving

D. Combustion and centrifuging

22 Four reactions are labelled W, X, Y and Z.

W $C_6H_{12}O_6\,(s) + 6O_2\,(g) \rightarrow 6CO_2\,(g) + 6\,H_2O\,(l)$

X $2HCl\,(aq) + Na_2CO_3\,(aq) \rightarrow 2NaCl\,(aq) + H_2O\,(l) + CO_2\,(g)$

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

Z $CuCO_3\,(s) \rightarrow CuO\,(s) + CO_2\,(g)$

Which row correctly identifies the types of reactions?

	precipitation	*combustion*	*decomposition*	*neutralisation*
A.	W	X	Y	Z
B.	Y	W	Z	X
C.	Y	X	Z	W
D.	Z	W	Y	X

23 A student carried out a series of tests on four unknown solid samples labelled W, X, Y, and Z and recorded their results in the table given.

Sample	*Melting point (^oC)*	*Conductivity in solid state*	*Conductivity in molten state*
W	1900	None	None
X	185	None	None
Y	932	None	Good
Z	250	Good	Good

Which row correctly matches the samples with the type of bonding present?

	W	*X*	*Y*	*Z*
A.	Covalent molecular	Covalent network	Ionic	Metallic
B.	Metallic	Ionic	Covalent network	Covalent molecular
C.	Covalent network	Covalent molecular	Ionic	Metallic
D.	Metallic	Covalent molecular	Covalent network	Ionic

24 Two compounds containing nitrogen, ammonia (NH_3) and the ammonium ion (NH_4^+), have different molecular shapes.

What is the correct molecular shape for each of these compounds?

	Ammonia	*Ammonium Ion*
A.	Trigonal pyramid	Tetrahedral
B.	Trigonal pyramid	Square Planar
C.	Trigonal Planar	Tetrahedral
D.	Trigonal Planar	Square planar

25 How much water needs to be added to 200.00 mL of 0.75 mol L^{-1} zinc chloride solution to change its concentration to 0.500 mol L^{-1}?

A. 100.00 mL

B. 133.00 mL

C. 150.00 mL

D. 300.00 mL

26 Consider the following electron transfer reaction.

$$2HNO_3\ (aq) + Cu\ (s) + 2H^+\ (aq) \rightarrow 2NO_2\ (g) + Cu^{2+}\ (aq) + 2H_2O\ (l)$$

Which of the following statements is correct?

A. HNO_3 is the reductant and Cu is the oxidant.

B. HNO_3 is the reductant and H^+ is the oxidant.

C. Cu is the reductant and H^+ is the oxidant.

D. Cu is the reductant and HNO_3 is the oxidant.

27 A hydrocarbon contains carbon and hydrogen only. One litre of this hydrocarbon is combusted in excess oxygen to produce 3.0 L of carbon dioxide gas and 4.0 L of water vapour measured at the same temperature and pressure.

What is the volume of oxygen gas consumed at the end of this reaction?

A. 1.0 L

B. 5.0 L

C. 6.0 L

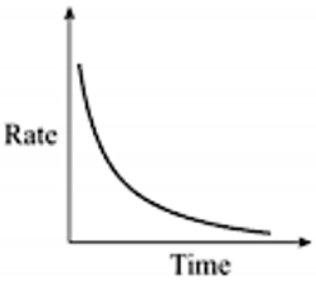
D. 7.0 L

28 Hydrogen peroxide spontaneously decomposes into oxygen and water.

$$2H_2O_2\ (l) \rightarrow 2H_2O\ (l) + O_2\ (g)$$

Which graph shows the relationship between the rate of consumption of hydrogen peroxide and time?

A.



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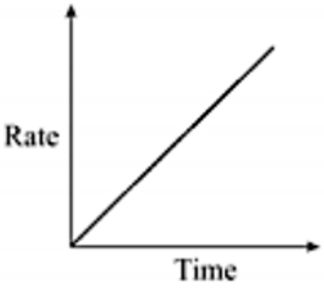

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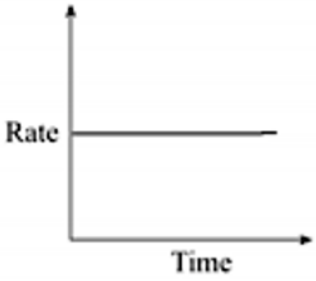

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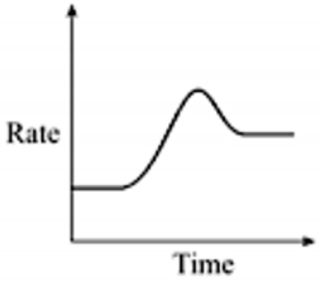


29 Use the data provided to determine ΔH for the following reaction.

$$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (g)$$

Data:

$N_2(g) + O_2\ (g) \rightarrow 2NO\ (g)$	$\Delta H = -180.5$ kJ
$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$	$\Delta H = -91.8$ kJ
$H_2\ (g) + \frac{1}{2}O_2\ (g) \rightarrow H_2O\ (g)$	$\Delta H = -241.8$ kJ

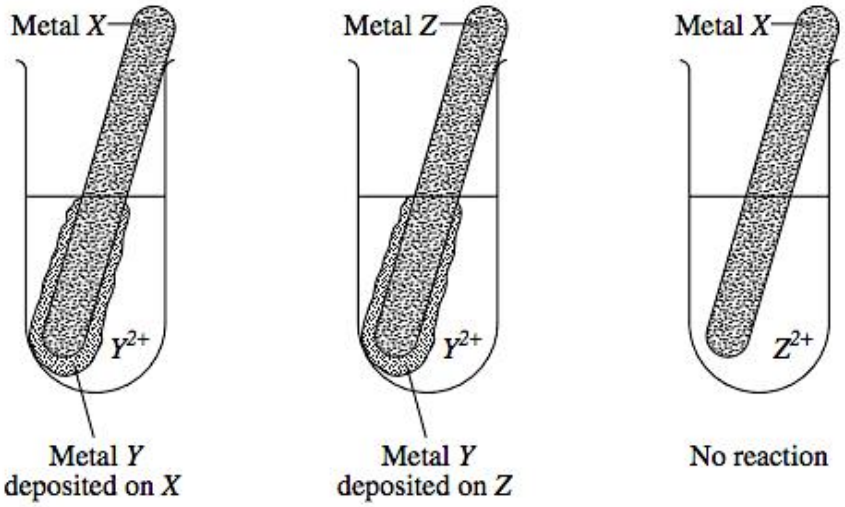
A. –1628.2 kJ

B. –514.1 kJ

C. –330.5 kJ

D. +1273.4 kJ

30 A student performed the following tests to investigate the relative activity of metals. In each test a metal strip was placed in a solution containing ions of a different metal. The results are shown in the diagrams below.



What is the order of activity of the metals based on these results?

A. Y < Z < X

B. Y < X < Z

C. X < Y < Z

D. Z < X < Y

Section II – 40 marks

Attempt Questions 31 – 37

Allow about 50 minutes for this section

- Answer all questions using the spaces provided in the written response booklet. The number of lines available gives an indication for the expected length of response.
- The marks for each question and the corresponding parts are indicated in the questions and on the sections below as well as on the written response booklet.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of the written response booklet. If you use this space, clearly indicate which question you are answering and direct the examiner to your answer.
- Write neatly to ensure that all responses are legible once scanned and uploaded to the google classroom as a pdf document.

Question 31 (3 marks)

The table below details the atomic and ionic radius for two different elements.

Element	*Atomic radius (pm)*	*Ionic radius (pm)*
Sodium	0.186	0.097
Fluorine	0.071	0.133

Explain the differences in the measurements recorded with reference to the changes in the atomic and ionic structure of each element. **3**

Question 32 (6 marks)

A chemist conducted an experiment where 2.25 g of sodium hydrogen carbonate was reacted with 0.5 mol L^{-1} hydrochloric acid at 100 kPa and 273.15 K.

(a) Calculate the volume of hydrochloric acid needed for complete reaction of the sodium hydrogen carbonate **2**

(b) Calculate the volume and mass of carbon dioxide gas generated from this reaction. **4**

Question 33 (4 marks)

Explain each of the following phenomena with reference to the relevant gas law in each case:

(a) A helium balloon released into the atmosphere increases in volume as it rises to higher altitudes. **2**

(b) Two separate balloons containing different gases (helium and nitrogen) were weighed and found to have different masses. Each balloon was filled with 2.0 L of gas at standard room temperature and pressure. **2**

Question 34 (8 marks)

The concentration of a potassium hydroxide solution can be determined by reacting it with sulfuric acid and measuring the temperature change of the solution.

Various volumes of 1.0 mol L^{-1} sulfuric acid solution were mixed with 12.0 mL of a potassium hydroxide solution of unknown concentration and sufficient deionised water was added to make the volume of the resulting solution 20.0 mL. The change in temperature of each solution was measured.

The data are given in the table below

Volume of 1.0 mol L^{-1} sulfuric acid added (mL)	*Temperature increase (^oC)*
0.0	0.00
1.0	1.80
2.0	3.30
3.0	5.40
4.0	6.60
5.0	6.70
6.0	6.60

By graphing the data in the table and performing the relevant calculations, determine the concentration of the potassium hydroxide solution. **8**

Question 35 (4 marks)

A student performed the following procedure to determine the effect of concentration on the rate of a reaction.

1. *Set up 5 test tubes in a test tube rack.*
2. *Pour 6 mL of 1.0 molL^{-1} HCl to the first test tube.*
3. *Draw up 1mL of the solution from test tube 1 and put it in test tube 2. Dilute the acid in test tube 2 with 4 ml of water.*
4. *Draw up 1 mL of solution from test tube 2 and put it in test tube 3. Dilute the acid in test tube 3 with 4 ml of water.*
5. *Repeat the dilutions for test tubes 4 and 5.*
6. *Tear a strip of magnesium ribbon into 5 x 1 cm pieces*
7. *Add the Mg to test tube 1 and time the reaction with a stopwatch.*
8. *Repeat the reaction and timing for the rest of the acid solutions.*
9. *Record your results in a table.*

Assess the procedure for reliability and validity **4**

Question 36 (7 marks)

An electrochemical cell is represented below.

$$Pt \mid Fe^{2+}(aq), Fe^{3+}(aq) \parallel Br_2(aq), Br^-(aq) \mid Pt$$

(a) Write the relevant half equations and the balanced net ionic equation for the overall cell reaction. **2**

(b) Calculate the standard cell potential **1**

(c) Identify the direction of anion flow (→ or ←), anode, cathode and solutions by labelling the diagram provided in the written response booklet. **3**

(d) What is the function of the salt bridge? **1**

Question 37 (8 marks)

Ammonium chloride can be formed by the reaction of hydrochloric acid with ammonia.

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl\ (s)$$

The following data applies to the formation of ammonium chloride at 298K.

	NH_3 (g)	*HCl(g)*	*NH_4Cl(s)*
ΔH_f^o (kJ mol^{-1})	-45.6	-92.3	-315.5
ΔS_f^o (J K^{-1} mol^{-1})	+192.5	+186.6	+94.6
ΔG_f^o (kJ mol^{-1})	-16.3	-95.4	-203.8

(a) Show that the change in enthalpy is –177.6 kJ / mol **2**

(b) Show that the change in entropy is –284.5 J K^{-1} mol^{-1} **2**

(c) Calculate the change in Gibb's free energy **2**

(d) Use your calculations to comment on the spontaneity of this reaction at 298 K **2**

End of Theory Examination

2021

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YEAR 11 THEORY EXAMINATION

Chemistry (Solutions)

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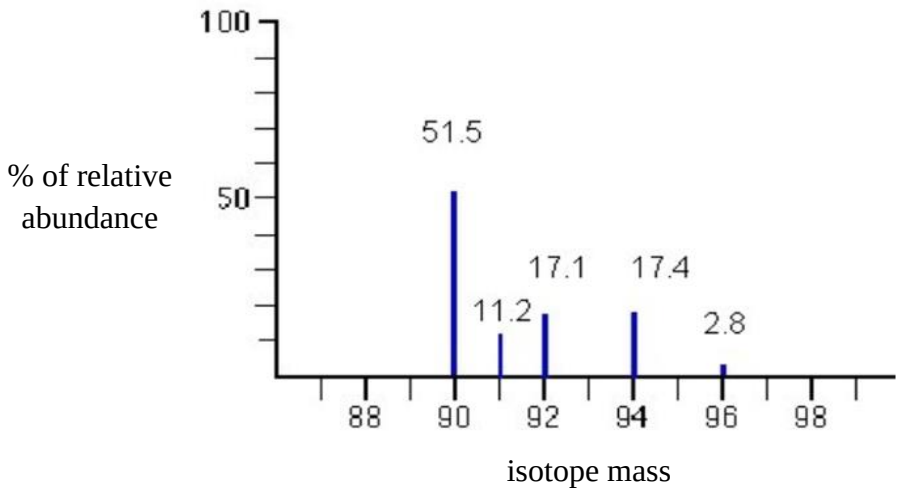

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Which statement best describes what this means?

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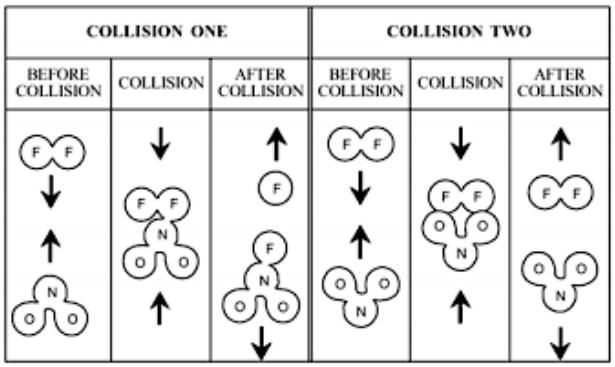

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B. orientation

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D. concentration

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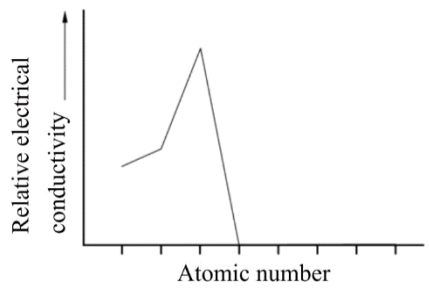
B. The total number of moles is always the same.

C. The total mass is always the same.

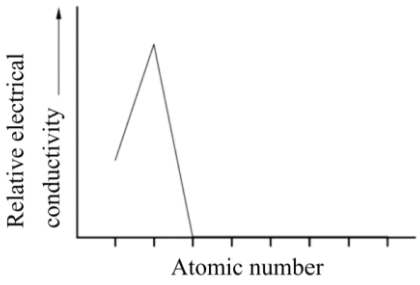
D. The amount of energy in the products and reactants is always the same.

14 Which of the following graphs is a correct representation of the relative electrical conductivities of elements across the third period of the periodic table.

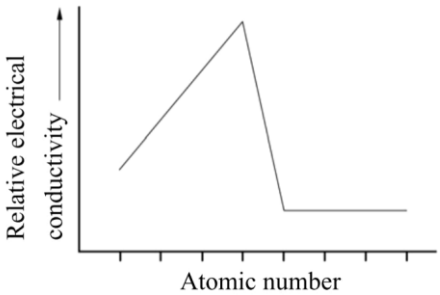
A.



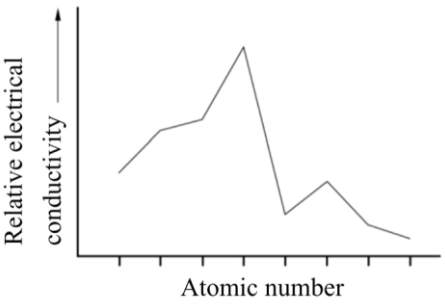
B.



C.



D.



15 Why do dust particles suspended in the air inside unheated grain silos sometimes react explosively?

A. They have high kinetic energy.

B. There is a catalytic effect on the dust.

C. There is a large surface area for the reaction.

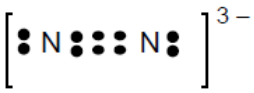
D. The reaction has high activation energy.

16 At a high temperature calcium will react with nitrogen to form Calcium nitride

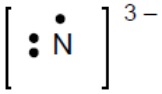
$$3Ca\ (s)\ +\ N_2\ (g)\ \rightarrow\ Ca_3N_2\ (s)$$

Which of the following Lewis electron dot structures is the correct representation of the nitride ion present?

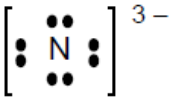
A.



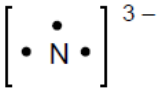
B.



C.



D.



17 100,000 t of copper ore contains 4.5% w/w of chalcopyrite, $CuFeS_2$.

What is the mass of chalcopyrite?

A. 4,500 kg

B. 4.5×10^6 kg

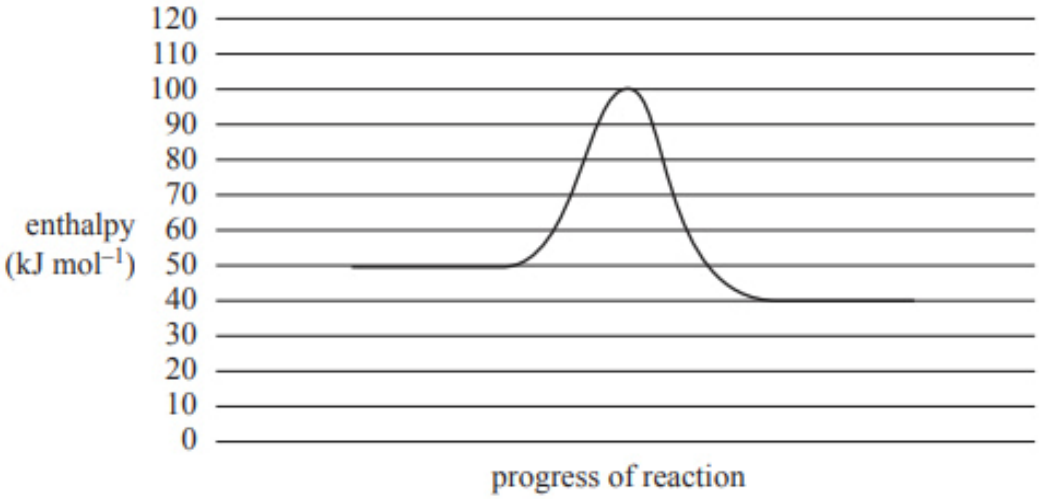
C. 4.5×10^9 kg

D. 4.5×10^4 kg

18 Which of the following alternatives gives the correct electron configuration for the excited state for the corresponding element?

	Atomic number	*Electron configuration*
A.	5	$1s^2 2s^2$
B.	6	$1s^2 2s^2 2p^2$
C.	**8**	**$1s^2 2s^2 2p^3 3s^1$**
D.	9	$1s^2 2s^2 2p^6$

19 An energy profile diagram is shown below.



Which of the following represents the energy profile of the reverse reaction?

	Final product energy (kJ mol^{-1})	*ΔH (kJ mol^{-1})*
A.	40	+10
B.	**50**	**+10**
C.	50	–10
D.	40	–10

20 Iodine is a solid at standard room temperature and pressure.

Which of the following statements concerning the structure of iodine is correct?

I Iodine has a giant covalent structure.

II Iodine molecules are held together by dispersion forces.

III Iodine atoms are held together in pairs by covalent bonds.

A. I only

B. II only

C. both I and III

D. both II and III

21 Which two processes are commonly used by Torres Strait Islanders and Aboriginal people to detoxify fruits?

A. Roasting and neutralising with acids

B. Filtering and dissolving

C. Heating and dissolving

D. Combustion and centrifuging

22 Four reactions are labelled W, X, Y and Z.

W $C_6H_{12}O_6\,(s) + 6O_2\,(g) \rightarrow 6CO_2\,(g) + 6\,H_2O\,(l)$

X $2HCl\,(aq) + Na_2CO_3\,(aq) \rightarrow 2NaCl\,(aq) + H_2O\,(l) + CO_2\,(g)$

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

Z $CuCO_3\,(s) \rightarrow CuO\,(s) + CO_2\,(g)$

Which row correctly identifies the types of reactions?

	precipitation	*combustion*	*decomposition*	*neutralisation*
A.	W	X	Y	Z
B.	**Y**	**W**	**Z**	**X**
C.	Y	X	Z	W
D.	Z	W	Y	X

23 A student carried out a series of tests on four unknown solid samples labelled W, X, Y, and Z and recorded their results in the table given.

Sample	*Melting point (^oC)*	*Conductivity in solid state*	*Conductivity in molten state*
W	1900	None	None
X	185	None	None
Y	932	None	Good
Z	250	Good	Good

Which row correctly matches the samples with the type of bonding present?

	W	*X*	*Y*	*Z*
A.	Covalent molecular	Covalent network	Ionic	Metallic
B.	Metallic	Ionic	Covalent network	Covalent molecular
C.	**Covalent network**	**Covalent molecular**	**Ionic**	**Metallic**
D.	Metallic	Covalent molecular	Covalent network	Ionic

24 Two compounds containing nitrogen, ammonia (NH_3) and the ammonium ion (NH_4^+), have different molecular shapes.

What is the correct molecular shape for each of these compounds?

	Ammonia	*Ammonium Ion*
A.	**Trigonal pyramid**	**Tetrahedral**
B.	Trigonal pyramid	Square Planar
C.	Trigonal Planar	Tetrahedral
D.	Trigonal Planar	Square planar

25 How much water needs to be added to 200.00 mL of 0.75 mol L^{-1} zinc chloride solution to change its concentration to 0.500 mol L^{-1}?

A. 100.00 mL

B. 133.00 mL

C. 150.00 mL

D. 300.00 mL

26 Consider the following electron transfer reaction.

$$2HNO_3\ (aq) + Cu\ (s) + 2H^+\ (aq) \rightarrow 2NO_2\ (g) + Cu^{2+}\ (aq) + 2H_2O\ (l)$$

Which of the following statements is correct?

A. HNO_3 is the reductant and Cu is the oxidant.

B. HNO_3 is the reductant and H^+ is the oxidant.

C. Cu is the reductant and H^+ is the oxidant.

D. Cu is the reductant and HNO_3 is the oxidant.

27 A hydrocarbon contains carbon and hydrogen only. One litre of this hydrocarbon is combusted in excess oxygen to produce 3.0 L of carbon dioxide gas and 4.0 L of water vapour measured at the same temperature and pressure.

What is the volume of oxygen gas consumed at the end of this reaction?

A. 1.0 L

B. 5.0 L

C. 6.0 L

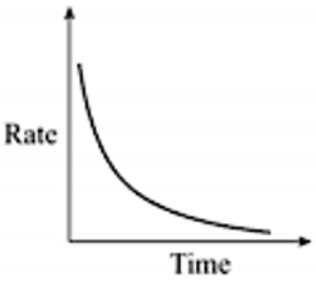
D. 7.0 L

28 Hydrogen peroxide spontaneously decomposes into oxygen and water.

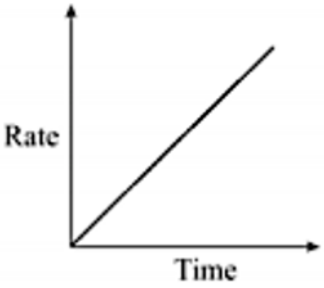
$$2H_2O_2\ (l) \rightarrow 2H_2O\ (l) + O_2\ (g)$$

Which graph shows the relationship between the rate of consumption of hydrogen peroxide and time?

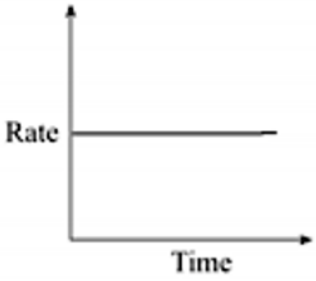
A.



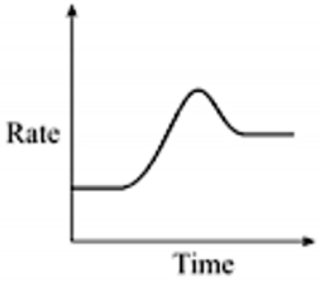
B.



C.



D.



29 Use the data provided to determine ΔH for the following reaction.

$$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (g)$$

Data:

$N_2(g) + O_2\ (g) \rightarrow 2NO\ (g)$	$\Delta H = -180.5$ kJ
$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$	$\Delta H = -91.8$ kJ
$H_2\ (g) + \frac{1}{2}O_2\ (g) \rightarrow H_2O\ (g)$	$\Delta H = -241.8$ kJ

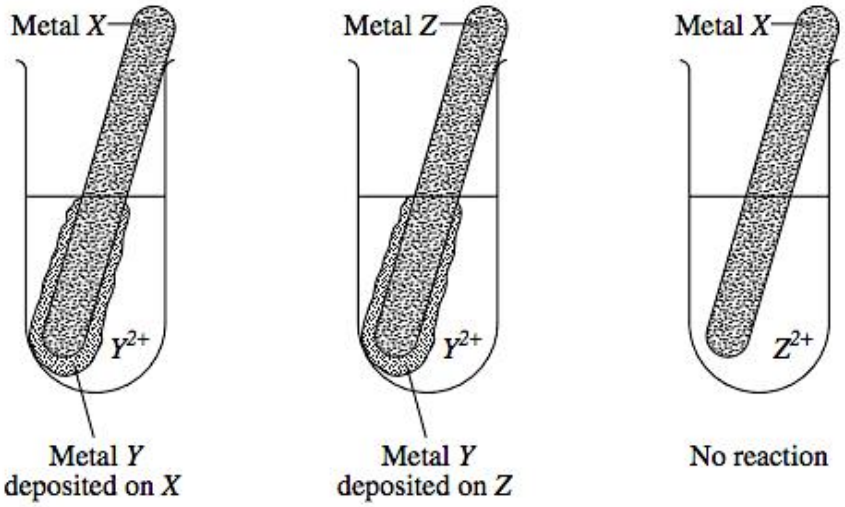
A. –1628.2 kJ

B. –514.1 kJ

C. –330.5 kJ

D. +1273.4 kJ

30 A student performed the following tests to investigate the relative activity of metals. In each test a metal strip was placed in a solution containing ions of a different metal. The results are shown in the diagrams below.



What is the order of activity of the metals based on these results?

A. Y < Z < X

B. Y < X < Z

C. X < Y < Z

D. Z < X < Y

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 ○
11.	A ○	B ○	C ○	D ○
12.	A ○	B ○	C ○	D ○
13	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15.	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○
19.	A ○	B ○	C ○	D ○
20.	A ○	B ○	C ○	D ○
21.	A ○	B ○	C ○	D ○
22.	A ○	B ○	C ○	D ○
23	A ○	B ○	C ○	D ○
24.	A ○	B ○	C ○	D ○
25.	A ○	B ○	C ○	D ○
26.	A ○	B ○	C ○	D ○
27.	A ○	B ○	C ○	D ○
28.	A ○	B ○	C ○	D ○
29.	A ○	B ○	C ○	D ○
30.	A ○	B ○	C ○	D ○

Section II – 40 marks

Attempt Questions 31 – 37

Allow about 50 minutes for this section

- Answer all 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 and direct the examiner to your answer.

Question 31 (3 marks)

The table below details the atomic and ionic radius for two different elements.

Element	*Atomic radius (pm)*	*Ionic radius (pm)*
Sodium	0.186	0.097
Fluorine	0.071	0.133

Explain the differences in the measurements recorded with reference to the changes in the atomic and ionic structure of each element. **3**

Sample answer:

Sodium is located in group 1 of the periodic table and elements in this area lose one electron when they form ions. The loss of one electron causes a contraction in the radius since there are fewer electrons available to share the force of attraction by the nucleus. This accounts for the change in radius observed from 0.186 *pm* to 0.097 *pm*.

Fluorine is located in group 7 / 17 of the periodic table and elements in this area gain one electron when they form ions. The presence of an extra electron causes an expansion in the radius since there are now more electrons available to share the force of attraction by the nucleus. This accounts for the change in radius observed from 0.071 *pm* to 0.133 *pm*.

Marking Criteria	*Mark(s)*
• Correctly explains the changes in radius for BOTH elements with reference to changes in the number of electrons.	3
• Correctly explains the changes in radius for ONE element.	2
• Provides some relevant information.	1

Question 32 (6 marks)

A chemist conducted an experiment where 2.25 g of sodium hydrogen carbonate was reacted with 0.5 mol L^{-1} hydrochloric acid at STP conditions in a laboratory.

(a) Calculate the volume of hydrochloric acid needed for complete reaction of the sodium hydrogen carbonate **2**

Sample answer:

$n(NaHCO_3) = 2.25 / 84 = 0.0268$ mol

$V(HCl) = n / c = 0.0268 / 0.5 = 0.053566$ L = 53.7 mL

Marking Criteria	*Mark(s)*
• Correct calculation of V of HCl • Correct calculation of moles	2
• ONE correct calculation	1

(b) Calculate the volume and mass of carbon dioxide gas generated from this reaction. **4**

Sample answer:

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

Mole ratio from balanced eqn 1 mol $NaHCO_3$ = 1 mol CO_2

$n(CO_2) = 0.0268$ mol , Mass CO_2 = n x M = 0.0268 x 44 = 1.18 g

Volume of CO_2 gas = n x V_m at STP = 0.0268 x 22.71L = 0.609 L

Marking Criteria	*Mark(s)*
• Correct calculation of both mass and volume of CO_2 with correct units and 3 significant fig.	4
• One error in calculation OR answer not in correct significant figures	3
• Correct calculation of either mass OR Volume	2
• One correct calculation	1

Question 33 (4 marks)

Explain each of the following phenomena with reference to the relevant gas law in each case:

(a) A helium balloon released into the atmosphere increases in volume as it rises to higher altitudes. **2**

Sample answer:

External atmospheric pressure on the balloon decreases as it ascends. To compensate for the reduced external pressure, the gas volume in the balloon increases, causing the balloon to expand as it ascends – Boyle's Law.

Marking Criteria	*Mark(s)*
• Correct and complete explanation for balloon and relating Boyle's Law.	2
• Outline of reason for balloon expanding	1

(b) Two separate balloons containing different gases (helium and nitrogen) were weighed and found to have different masses. Each balloon was filled with 2.0 L of gas at standard room temperature and pressure. **2**

Sample answer:

The two gases have different molar mass but will occupy the same volume at the same conditions of temperature and pressure – Avogadro's Law

Marking Criteria	*Mark(s)*
• Correct explanation and complete explanation for different masses but same volume and relating to Avogadro's Law.	2
• Outline of the reason for different masses.	1

NOTE: PV = nRT is the combined gas law. This Q specifically refers to Avogadro's Law.

Question 34 (8 marks)

The concentration of a potassium hydroxide solution can be determined by reacting it with sulfuric acid and measuring the temperature change of the solution.

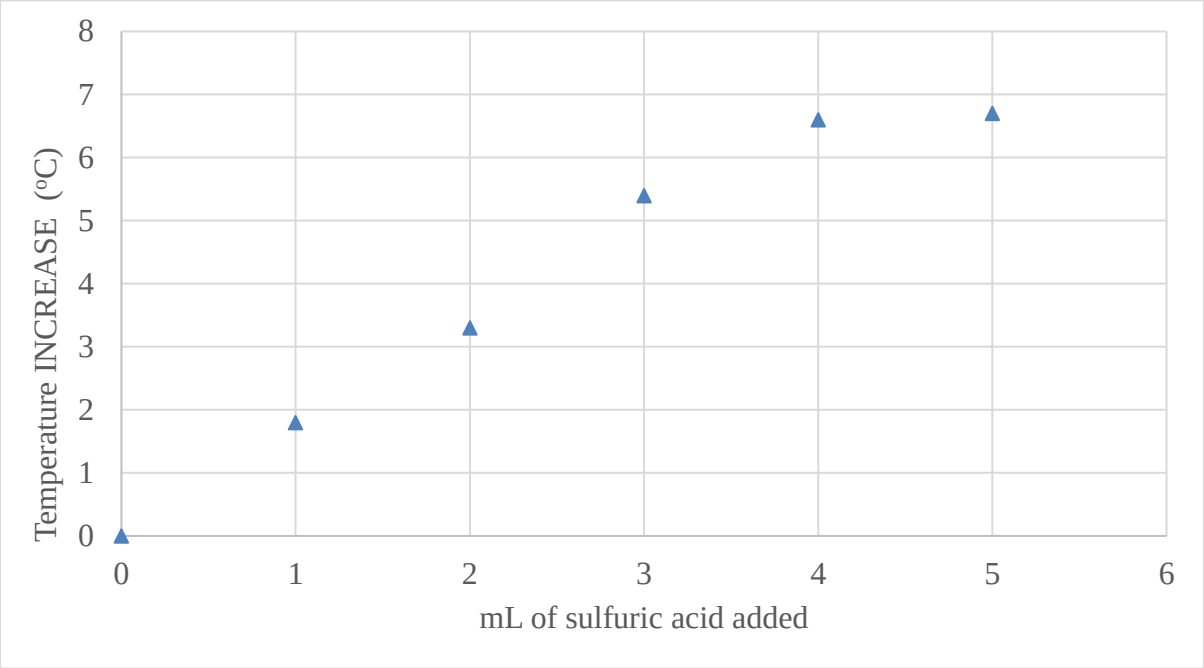
Various volumes of 1.0 mol L^{-1} sulfuric acid solution were mixed with 12.0 mL of a potassium hydroxide solution of unknown concentration and sufficient deionised water was added to make the volume of the resulting solution 20.0 mL. The change in temperature of each solution was measured.

The data are given in the table below

Volume of 1.0 mol L^{-1} sulfuric acid added (mL)	*Temperature increase (^oC)*
0.0	0.00
1.0	2.50
2.0	5.20
3.0	6.15
4.0	6.10
5.0	6.20
6.0	6.16

By graphing the data in the table and performing the relevant calculations, determine the concentration of the potassium hydroxide solution. **8**

Sample answer:



Calculations

Intersection at 3.6 mL or 4.0 mL

$2KOH\ (aq) + H_2SO_4\ (aq) \rightarrow 2H_2O\ (l) + K_2SO_4\ (aq)$

mol H_2SO_4 = c x V = 1.0 x 0.0036 (0.0040) = 0.0036 (0.0040) mol

therefore mol KOH = 2 x 0.0036 (0.0040) = 0.0072 (0.008) mol

[KOH] = mol/V = 0.0072 / 0.0012 = 6 mol L^{-1} or 0.0080 / 0.012 = 0.67 mol L^{-1}

Range of 3.6 to 4.0 mL were accepted values.

5.0 mL not accepted as it is past the endpoint as seen in the table.

Marking Criteria	*Mark(s)*
• Correct axes used sensible units • Correct plots and correct intersecting lines • Balanced chemical equation for the reaction • Provides all relevant calculations to determine the concentration of the potassium hydroxide solution	8
• Correct axes used sensible units • Correct plots and correct intersecting lines • Balanced chemical equation for the reaction • Provides most relevant calculations to determine the concentration of the potassium hydroxide solution OR • Correct axes used sensible units • Correct plots • Balanced chemical equation for the reaction • Provides all relevant calculations to determine the concentration of the potassium hydroxide solution	7
• Correct axes used sensible units • Correct plots and correct intersecting lines • Provides all relevant calculations to determine the concentration of the potassium hydroxide solution	6
• Most correct graphing and relevant calculations	5
• All correct graphing OR • Some correct graphing and calculation	4
• Some correct graphing OR correct calculation	3

Question 35 (4 marks)

A student performed the following procedure to determine the effect of concentration on the rate of a reaction.

1. *Set up 5 test tubes in a test tube rack.*
2. *Pour 6 mL of 1.0 molL^{-1} HCl to the first test tube.*
3. *Draw up 1mL of the solution from test tube 1 and put it in test tube 2. Dilute the acid in test tube 2 with 4 ml of water.*
4. *Draw up 1 mL of solution from test tube 2 and put it in test tube 3. Dilute the acid in test tube 3 with 4 ml of water.*
5. *Repeat the dilutions for test tubes 4 and 5.*
6. *Tear a strip of magnesium ribbon into 5 x 1 cm pieces*
7. *Add the Mg to test tube 1 and time the reaction with a stopwatch.*
8. *Repeat the reaction and timing for the rest of the acid solutions.*
9. *Record your results in a table.*

Assess the procedure for reliability and validity **4**

Sample answer:

This procedure is not reliable as only one test is done for each dilution. To be reliable the tests should be repeated, and results replicated.

The procedure is valid as there is one independent variable, the concentration of the acid and a dependant variable, the time for the reaction to take place. All other variables were kept constant.

Marking Criteria	*Mark(s)*
• Assessed the procedure for reliability and validity	4
• Assessed the procedure for reliability and outlined the validity OR Vice versa	3
• Outlined reliability and validity OR • Assessed the procedure for reliability OR validity	2
• Gave some relevant information	1

Question 36 (7 marks)

An electrochemical cell is represented below.

$$Pt \mid Fe^{2+}(aq), Fe^{3+}(aq) \parallel Br_2(aq), Br^-(aq) \mid Pt$$

(a) Write the relevant half equations and the balanced net ionic equation for the overall cell reaction. **2**

Sample answer:

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$$

$$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$$

$$Br_2(aq) + 2Fe^{2+}(aq) \rightarrow 2Fe^{3+}(aq) + 2Br^-(aq)$$

Marking Criteria	*Mark(s)*
• Correct half equations and overall equation	2
• A correct equation	1

(b)

Calculate the standard cell potential **1**

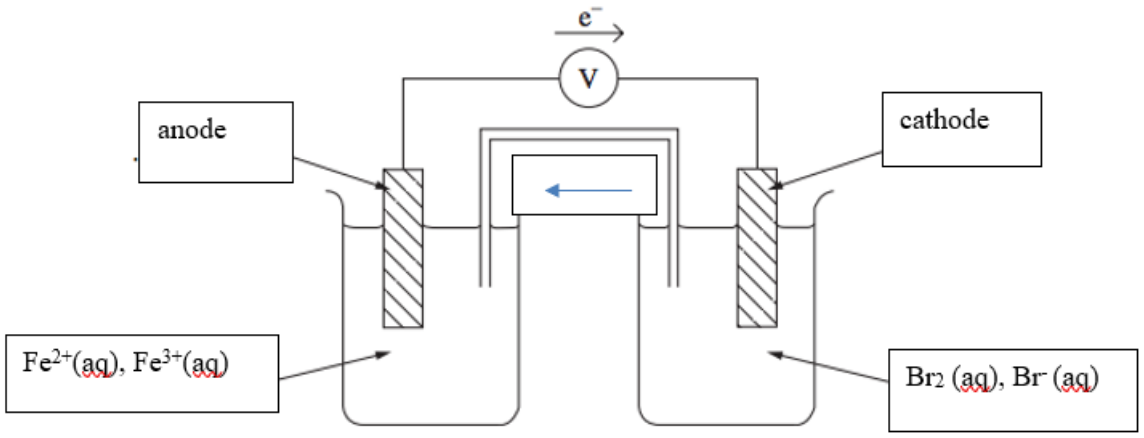
Sample answer:

$E^o = 1.10 - 0.77 = 0.33$ V

Marking Criteria	*Mark(s)*
• Correct calculation of the cell potential	1

(c) Identify the direction of anion flow (→ or ←), anode, cathode and solutions by labelling the following diagram. **3**

Sample answer:



Marking Criteria	*Mark(s)*
• 5 labels correct	3
• 3 or 4 labels correct	2
• 2 labels correct	1

(d) What is the function of the salt bridge? **1**

Sample answer:

To facilitate the migration of ions from one half cell to another to complete the circuit.

Marking Criteria	*Mark(s)*
• Correctly outlines the function of the salt bridge	1

Question 37 (8 marks)

Ammonium chloride can be formed by the reaction of hydrochloric acid with ammonia.

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl\ (s)$$

The following data applies to the formation of ammonium chloride at 298K.

	NH_3 (g)	*HCl(g)*	*NH_4Cl(s)*
ΔH_f^o (kJ mol^{-1})	-45.6	-92.3	-315.5
ΔS_f^o (J K^{-1} mol^{-1})	+192.5	+186.6	+94.6
ΔG_f^o (kJ mol^{-1})	-16.3	-95.4	-203.8

(a) Show that the change in enthalpy is –177.6 kJ / mol **2**

Sample answer:

$$\Delta H^o = \Sigma H_f\,(\text{products}) - \Sigma H_f\,(\text{reactants})$$
$$= -315.5 - (-45.6 + -92.3)$$
$$= -177.6\ \text{kJ/mol}$$

Marking Criteria	*Mark(s)*
• Correct answer and relevant working shown	2
• Some relevant working shown	1

(b) Show that the change in entropy is –284.5 J K^{-1} mol^{-1} **2**

Sample answer:

$$\Delta S^o = \Sigma S\,(\text{products}) - \Sigma S\,(\text{reactants})$$
$$= +94.6 - (+192.5 + 186.6)$$
$$= -284.5\ \text{J K}^{-1}\ \text{mol}^{-1}$$

Marking Criteria	*Mark(s)*
• Correct answer and relevant working shown	2
• Some relevant working shown	1

(c) Calculate the change in Gibb's free energy **2**

Sample answer:

ΔS^o = - 284.5 J K^{-1} $mol^{-1.}$ = - 0.2845 kJ K^{-1} mol^{-1}

$\Delta G^o = \Delta H^o - T\Delta S^o$

= - 177.6 – (298 x - 0.2845)

= -92.82 kJ mol^{-1}

Marking Criteria	*Mark(s)*
• Correct answer and relevant working shown	2
• Some relevant working shown	1

(d) Use your calculations to comment on the spontaneity of this reaction at 298 K **2**

Sample answer:

The negative value for ΔG^o indicates that the reaction is spontaneous at 298K.

The negative value for ΔH^o also indicates that the reaction is spontaneous at 298K.

Marking Criteria	*Mark(s)*
• Refers to two calculations in determining the spontaneity of the reaction	2
• Indicates that the reaction is spontaneous at 298K	1