



Sydney Girls High School

2024

YEAR 11

Chemistry

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Student Number

PART A & B

General Instructions

- Reading time – 5 minutes
- Working time – 90 minutes
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used

Total marks – 50

Part A – Pages 2-6

10 marks

- Attempt Questions 1 – 10

Part B – Pages 7-12

21 marks

- Attempt Questions 11 – 15

Part C – Pages 13-16

19 marks

- Attempt Questions 16 – 18

Part A – 10 marks**Attempt Questions 1 – 10**

Use the multiple-choice answer sheet for Questions 1–10

1 In a galvanic cell, what is the pathway of electron flow?

	Direction	Medium
(A)	Anode to cathode	Salt bridge
(B)	Anode to cathode	External wire
(C)	Cathode to anode	Salt bridge
(D)	Cathode to anode	External wire

2 Which of the following reactions show a decrease in entropy?

- (A) $\text{NaCl} (s) \rightarrow \text{NaCl} (aq)$
- (B) $\text{N}_2\text{O} (g) + \text{NO}_2 (g) \rightarrow 3\text{NO} (g)$
- (C) $\text{CaCO}_3 (s) \rightarrow \text{CaO} (g) + \text{CO}_2 (g)$
- (D) $6\text{CO}_2 (g) + 6\text{H}_2\text{O} (l) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 (s) + 6\text{O}_2 (g)$

3 Aboriginal and Torres Strait Islander peoples have long been using the ideas of solubility to detoxify foods such as cycads.

Which row of the table correctly identifies the purpose of these processes?

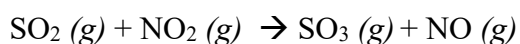
	Crushing the cycad seeds	Soaking the crushed seeds in water
(A)	Increases surface area	Leaches out water insoluble toxins
(B)	Decreases surface area	Leaches out water insoluble toxins
(C)	Decreases surface area	Leaches out water soluble toxins
(D)	Increases surface area	Leaches out water soluble toxins

- 4 A student was given three metal samples, but they forgot to label the samples. The student then conducted the following tests.

Metal	Reaction with water	Reaction with acid	Reaction with oxygen
1	No visible reaction	No visible reaction	No visible reaction
2	White coating formed in near-boiling water	Reacted vigorously with cold sulfuric acid	Burned readily as a thin foil
3	No visible reaction	Reacted slowly with warm sulfuric acid	Formed a red/brown layer when heated in air

Which of the following metals is most likely to be the identity of metal 2?

- (A) Lead
 - (B) Silver
 - (C) Copper
 - (D) Magnesium
- 5 What is the oxidising agent in the following reaction:



- (A) SO_2
- (B) NO_2
- (C) SO_3
- (D) NO

- 6 When dilute hydrochloric acid is added to solid zinc carbonate, a colourless gas is evolved and the solid dissolves.

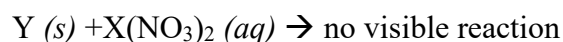
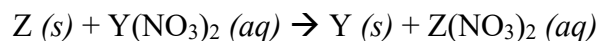
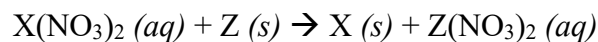
What is the correctly balanced net ionic equation for this reaction?

- (A) $\text{ZnCO}_3(s) + 2\text{H}^+(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
- (B) $\text{ZnCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
- (C) $\text{ZnCO}_3(s) + \text{H}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Cl}^-(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
- (D) $\text{ZnCO}_3(s) + 2\text{H}^+(aq) + 2\text{Cl}^-(aq) \rightarrow \text{Zn}^{2+}(aq) + 2\text{Cl}^-(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$

- 7 When ammonium nitrate dissolves in water, the temperature of the water decreases because

- (A) as the bonds in the products form, more energy is released than is required to break the bonds in the reactants
- (B) as the bonds in the products form, more energy is absorbed than is released to break the bonds in the reactants
- (C) as the bonds in the products form, less energy is released than is required to break the bonds in the reactants
- (D) as the bonds in the products form, less energy is absorbed than is released to break the bonds in the reactants

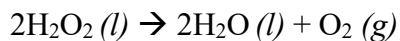
- 8 A student was investigating the reactivity of three unknown metals (X, Y and Z) by placing a metal strip in a solution containing ions of a different metal. She recorded the following balanced chemical equations:



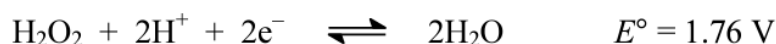
Which of the following correctly places the three metals in order of increasing reactivity?

- (A) Y, X, Z
- (B) Z, Y, X
- (C) X, Z, Y
- (D) Z, X, Y

- 9 Hydrogen peroxide decomposes according to the equation:

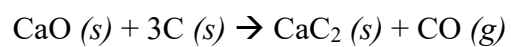


Using the following redox potentials, determine whether this decomposition reaction is spontaneous or not.



- (A) EMF = 2.46 V therefore spontaneous
- (B) EMF = 1.06 V therefore spontaneous
- (C) EMF = -1.06 V therefore non-spontaneous
- (D) EMF = -2.46 V therefore non-spontaneous

- 10** Use the standard enthalpy of formation values in the table below to calculate the enthalpy change for the formation of 1 kg of CaC_2 according to the following reaction:



$\Delta H_f \text{ CaO}$	-636 kJ mol^{-1}
$\Delta H_f \text{ CaC}_2$	-63 kJ mol^{-1}
$\Delta H_f \text{ CO}$	-111 kJ mol^{-1}

- (A) 7.2 kJ
(B) 462 kJ
(C) 573 kJ
(D) 7208 kJ

Part B – 21 marks

Attempt Questions 11 - 15

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 11 (3 marks)

The reactivity of a metal is significantly influenced by ionisation energy and atomic radius.

Explain how the reactivity of a metal is influenced by each of these properties. **3K**

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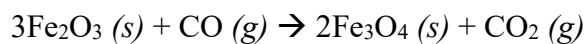
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Question 12 (4 marks)

Four equations and their ΔH values are shown:



Using the provided information and Hess's law, calculate the enthalpy change for the following reaction: **4A**



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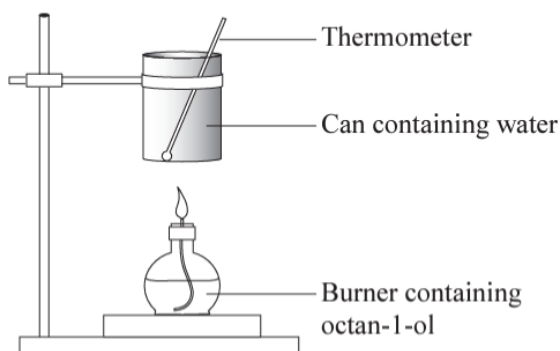
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Question 13 (3 marks)

A student used the apparatus shown to investigate the combustion of octan-1-ol ($\text{C}_8\text{H}_{17}\text{OH}$).



The following results were obtained by the student.

Mass of water heated	350 g
Mass of octan-1-ol burnt	0.80 g
Initial temperature of water	20.0°C

The following data are given.

Molar enthalpy of combustion of octan-1-ol	-5294 kJ mol ⁻¹
Molar mass of octan-1-ol	130.23 g mol ⁻¹

Assuming no energy released by this combustion is lost to the surroundings, calculate the final temperature of the water. **3A**

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Question 14 (6 marks)

An investigation was performed to measure the volume of hydrogen gas produced when a 5.0 g piece of magnesium metal reacted with a 0.1 mol L⁻¹ nitric acid solution at 20°C. The data collected was recorded in the table below.

Time (s)	Volume of hydrogen gas (mL)
0	0
10	29
20	41
30	44
40	45
50	46
60	46
70	46
80	46
90	46

Question 14 continues on page 11

a) Graph the results on the grid below.

3A



b) Use collision theory to explain how the shape of the graph would change if the 0.1 mol L⁻¹ nitric acid solution was heated to 40°C.

3K

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Question 15 (5 marks)

Five bottles labelled A, B, C, D and E contain one of the following solutions:

- Barium nitrate
- Lead(II) nitrate
- Hydrochloric acid
- Silver nitrate
- Sodium carbonate

To find out which solution was in each bottle, a student mixed solutions from pairs of bottles. The results of the tests were summarised in the table below. (NVR = no visible reaction).

	A	B	C	D	E
A	-	NVR	NVR	white precipitate	white precipitate
B	NVR	-	NVR	yellow precipitate	white precipitate
C	NVR	NVR	-	white precipitate	NVR
D	white precipitate	yellow precipitate	white precipitate	-	bubbles
E	white precipitate	white precipitate	NVR	bubbles	-

The only yellow precipitate that can be formed from these compounds is silver carbonate.

(a) Identify the five solutions.

3A

A	
B	
C	
D	
E	

(b) Write a balanced chemical equation to represent the reaction between bottle D and E.

2K

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Sydney Girls High School

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Student Number

2024

YEAR 11

Chemistry

PART C

General Instructions

- Reading time – 5 minutes
- Working time – 90 minutes
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper

Total marks – 50

Part A – Pages 2-6

10 marks

- Attempt Questions 1 – 10

Part B – Pages 7-12

21 marks

- Attempt Questions 11 – 15

Part C – Pages 13-16

19 marks

- Attempt Questions 16 – 18

Part C –19 marks

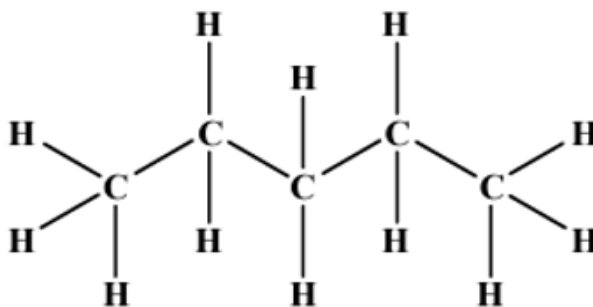
Attempt Questions 16 - 18

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 16 (4 marks)

The diagram below shows the gas pentane.



- a) Write a balanced chemical equation for the complete combustion of pentane.

2K

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- b) Given the following data, calculate the enthalpy change for this combustion reaction.

2K

Bond	Bond enthalpy (kJ mol ⁻¹)	Bond	Bond enthalpy (kJ mol ⁻¹)
C–H	414	O–H	463
C–C	346	O–O	144
C=O	804	O=O	498

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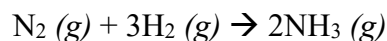
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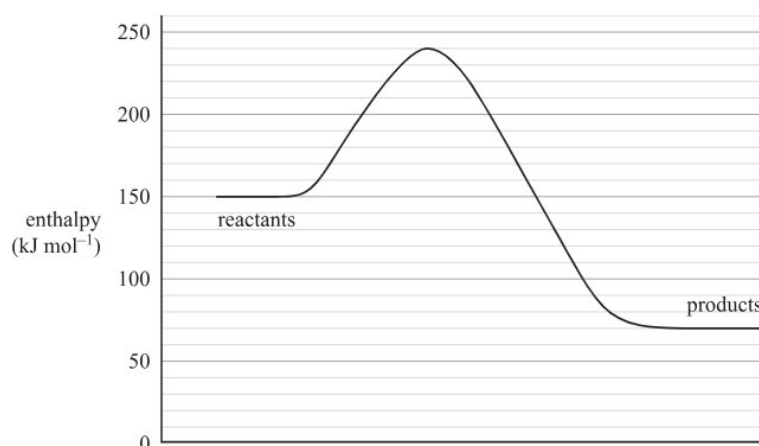
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Question 17 (7 marks)

Ammonia can be synthesised from nitrogen and hydrogen gas according to the following equation:



The energy profile diagram of this reaction is shown below:



a) What is the enthalpy change for this reaction?

1A

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b) The reaction is catalysed by iron metal.

Draw a labelled curve on the graph above to represent the catalysed reaction.

2K

c) Given the data in the table below, determine whether the uncatalysed synthesis of ammonia is spontaneous or non-spontaneous at 150°C.

4A

Substance	$\text{N}_2(\text{g})$	$\text{H}_2(\text{g})$	$\text{NH}_3(\text{g})$
Standard entropy ($\text{J mol}^{-1} \text{K}^{-1}$)	192	131	193

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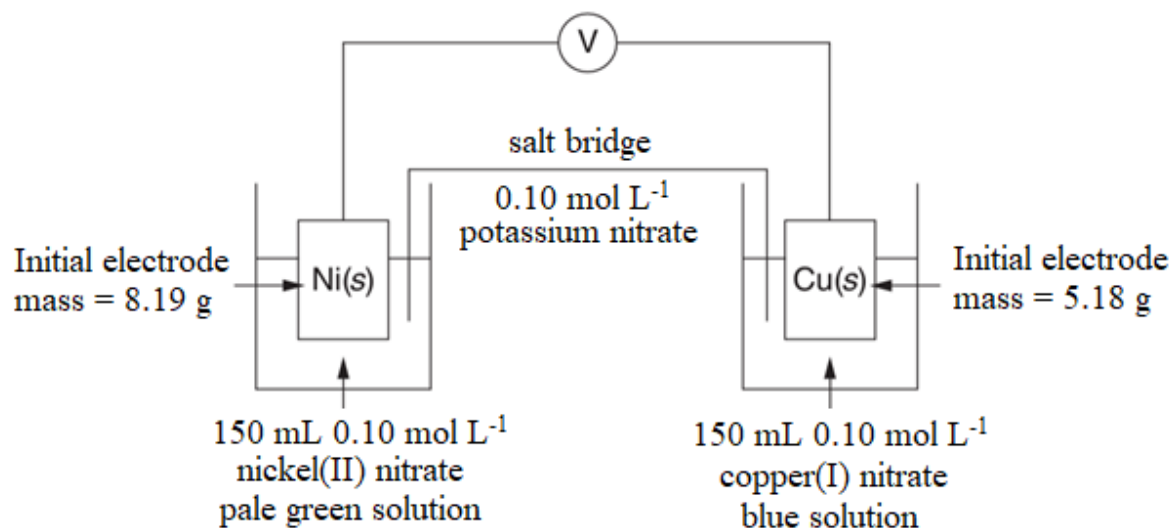
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Question 18 (8 marks)

A galvanic cell was constructed as shown in the diagram.



- a) Explain any colour changes observed as the reaction proceeds. Include relevant half equations. **2K**

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- b) After some time, the electrodes were removed from the solutions, dried and reweighed. The mass of the nickel electrode had changed by 1.0 g.

Calculate the new mass of the copper electrode. Include a balanced net ionic equation for the overall cell reaction.

4K

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- c) Calculate the final concentration of the nickel(II) nitrate solution.

2K

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End of Examination



Sydney Girls High School

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Student Number

2024

YEAR 11

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 90 minutes
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided on pages
- Write your student number on the multiple choice answer sheet and the cover page

Total marks – 50

Part A – Pages 2-6

10 marks

- Attempt Questions 1 – 10

Part B – Pages 7-12

21 marks

- Attempt Questions 11 – 15

Part C – Pages 13-16

19 marks

- Attempt Questions 16 – 18

Part A – 10 marks**Attempt Questions 1 – 10**

Use the multiple-choice answer sheet for Questions 1–10

1 In a galvanic cell, what is the pathway of electron flow?

	Direction	Medium
(A)	Anode to cathode	Salt bridge
(B)	Anode to cathode	External wire
(C)	Cathode to anode	Salt bridge
(D)	Cathode to anode	External wire

2 Which of the following reactions show a decrease in entropy?

- (A) $\text{NaCl (s)} \rightarrow \text{NaCl (aq)}$
- (B) $\text{N}_2\text{O (g)} + \text{NO}_2\text{ (g)} \rightarrow 3\text{NO (g)}$
- (C) $\text{CaCO}_3\text{ (s)} \rightarrow \text{CaO (g)} + \text{CO}_2\text{ (g)}$
- (D) $6\text{CO}_2\text{ (g)} + 6\text{H}_2\text{O (l)} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6\text{ (s)} + 6\text{O}_2\text{ (g)}$

3 Aboriginal and Torres Strait Islander peoples have long been using the ideas of solubility to detoxify foods such as Cycads.

Which row of the table correctly identifies the purpose of these processes?

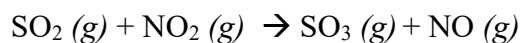
	Crushing the cycad seeds	Soaking the crushed seeds in water
(A)	Increases surface area	Leaches out water insoluble toxins
(B)	Decreases surface area	Leaches out water insoluble toxins
(C)	Decreases surface area	Leaches out water soluble toxins
(D)	Increases surface area	Leaches out water soluble toxins

- 4 A student was given three metal samples, but they forgot to label the samples. The student then conducted the following tests.

Metal	Reaction with water	Reaction with acid	Reaction with oxygen
1	No visible reaction	No visible reaction	No visible reaction
2	White coating formed in near-boiling water	Reacted vigorously with cold sulfuric acid	Burned readily as a thin foil
3	No visible reaction	Reacted slowly with warm sulfuric acid	Formed a red/brown layer when heated in air

Which of the following metals is most likely to be the identity of metal 2?

- (A) Lead
 - (B) Silver
 - (C) Copper
 - (D) Magnesium
- 5 What is the oxidising agent in the following reaction:



- (A) SO_2
- (B) NO_2
- (C) SO_3
- (D) NO

- 6 When dilute hydrochloric acid is added to solid zinc carbonate, a colourless gas is evolved and the solid dissolves.

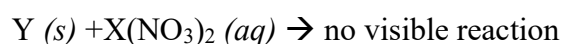
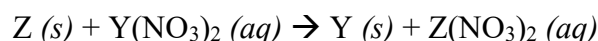
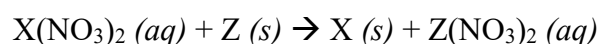
What is the correctly balanced net ionic equation for this reaction?

- (A) $\text{ZnCO}_3(s) + 2\text{H}^+(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
- (B) $\text{ZnCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
- (C) $\text{ZnCO}_3(s) + \text{H}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Cl}^-(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
- (D) $\text{ZnCO}_3(s) + 2\text{H}^+(aq) + 2\text{Cl}^-(aq) \rightarrow \text{Zn}^{2+}(aq) + 2\text{Cl}^-(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$

- 7 When ammonium nitrate dissolves in water, the temperature of the water decreases because

- (A) as the bonds in the products form, more energy is released than is required to break the bonds in the reactants
- (B) as the bonds in the products form, more energy is absorbed than is released to break the bonds in the reactants
- (C) as the bonds in the products form, less energy is released than is required to break the bonds in the reactants
- (D) as the bonds in the products form, less energy is absorbed than is released to break the bonds in the reactants

- 8 A student was investigating the reactivity of three unknown metals (X, Y and Z) by placing a metal strip in a solution containing ions of a different metal. She recorded the following balanced chemical equations:



Which of the following correctly places the three metals in order of increasing reactivity?

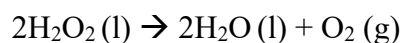
(A) Y, X, Z

(B) Z, Y, X

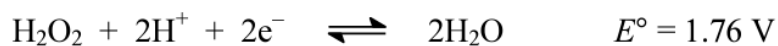
(C) X, Z, Y

(D) Z, X, Y

9 Hydrogen peroxide decomposes according to the equation:



Using the following redox potentials, determine whether this decomposition reaction is spontaneous or not.



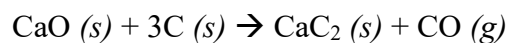
(A) EMF = 2.46 V therefore spontaneous

(B) EMF = 1.06 V therefore spontaneous

(C) EMF = -1.06 V therefore non-spontaneous

(D) EMF = -2.46 V therefore non-spontaneous

10 Use the standard enthalpy of formation values in the table below to calculate the enthalpy change for the formation of 1 kg of CaC_2 according to the following reaction:



$\Delta H_f \text{ CaO}$	-636 kJ mol^{-1}
$\Delta H_f \text{ CaC}_2$	-63 kJ mol^{-1}
$\Delta H_f \text{ CO}$	-111 kJ mol^{-1}

- (A) 7.2 kJ
- (B) 462 kJ
- (C) 573 kJ
- (D) 7208 kJ

Part B – 21 marks

Attempt Questions 11 - 15

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Answer the questions in the spaces provided.

Student Number

Show all relevant working in questions involving calculations.

Question 11 (3 marks)

The reactivity of a metal is significantly influenced by ionisation energy and atomic radius.

Explain how the reactivity of a metal is influenced by each of these properties.

3K

Criteria	Marks
Provides a thorough explanation of how the reactivity of a metal is influenced by ionisation energy and atomic radius.	3
Provides a sound explanation	2
Provides some relevant information	1

Sample answer:

Metals tend to lose electrons during chemical reactions. The more easily they lose the electrons, the higher the reactivity of the metal.

Ionisation energy is a measure of the amount of energy to remove an electron from an atom. Therefore, the lower the ionisation energy, the more easily electrons are lost and hence the higher the reactivity of the metal.

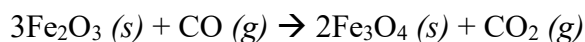
Electrons are held in atoms by their electrical attraction to the positive nucleus. The further away they are from the nucleus, the more weakly they are held. For metal atoms, the larger the radius of the atom, the more easily the outer electrons are lost and hence the higher the reactivity of the metal.

Question 12 (4 marks)

Four equations and their ΔH values are shown:



Using this information and Hess's law, calculate the enthalpy change for the following reaction:
4A



Criteria	Marks
Correctly calculates the enthalpy change	4
Provides the main steps of the calculation	3
Provides some relevant steps of the calculation	2
Provides some relevant information or working	1

Sample answer:

Multiply third equation by 3 and reverse:



Reverse first equation:



Multiply fourth equation by 2:



Add second equation:

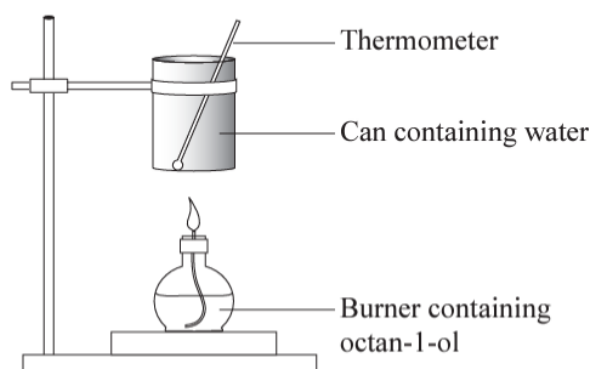




$$\Delta H = 2469 \text{ kJ mol}^{-1} + 110 \text{ kJ mol}^{-1} - 2232 \text{ kJ mol}^{-1} - 393 \text{ kJ mol}^{-1} \\ = -46 \text{ kJ mol}^{-1}$$

Question 13 (3 marks)

A student used the apparatus shown to investigate the combustion of octan-1-ol ($\text{C}_8\text{H}_{17}\text{OH}$).



The following results were obtained by the student.

Mass of water heated	350 g
Mass of octan-1-ol burnt	0.80 g
Initial temperature of water	20.0°C

The following data are given.

Molar enthalpy of combustion of octan-1-ol	-5294 kJ mol ⁻¹
Molar mass of octan-1-ol	130.23 g mol ⁻¹

Assuming no energy released by this combustion is lost to the surroundings, calculate the final temperature of the water.

3A

Criteria	Marks
Correctly calculates the final temperature of the water	3

Provides some correct steps of the calculation	2
Provides one relevant step	1

Sample answer:

$$n(\text{octan-1-ol}) = 0.80 \text{ g} / 130.23 \text{ g mol}^{-1} = 0.0061429778 \text{ mol}$$

$$\Delta H = -5294 \text{ kJ mol}^{-1}$$

$$\Delta H = q / n$$

$$q = 32.52092452 \text{ kJ}$$

$$q = mC\Delta T$$

$$32520.92452 \text{ J} = 350 \text{ g} \times 4.18 \text{ J/g}^{\circ}\text{C} \times \Delta T$$

$$\Delta T = 22^{\circ}\text{C}$$

$$\text{Final temperature} = 20 + 22.2 = 42^{\circ}\text{C}$$

Question 14 (6 marks)

An investigation was performed to measure the volume of hydrogen gas produced when a 5.0 g piece of magnesium metal reacted with a 0.1 mol L⁻¹ nitric acid solution at 20°C. The data collected was recorded in the table below.

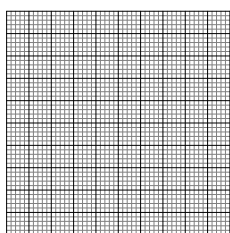
Time (s)	Volume of hydrogen gas (mL)
0	0
10	29
20	41
30	44
40	45

50	46
60	46
70	46
80	46
90	46

Question 14 continues on page 11

a) Graph the results on the grid below.

3A



Criteria	Marks
Provides correct graph - Correctly labelled axes including units - Appropriate scale - Correctly plotted points - Draws a curved line of best fit	3
Provides a substantially correct graph	2
Provides some relevant information	1

- b) Use collision theory to explain how the shape of the graph would change if the 0.1 mol L⁻¹ nitric acid solution was heated to 40°C. **3K**

Criteria	Marks
Refers to collision theory to correctly describe how the shape of the graph changes because of an increase in temperature	3
Identifies an increase in the rate of reaction because of an increase in temperature OR Applies collision theory to describe how ONE feature of the graph would change	2
Provides some relevant information	1

Sample answer:

As temperature increases, the average kinetic energy of particles increases. A higher kinetic energy allows particles to collide more often and with more energy to overcome the activation energy barrier. Therefore, as temperature increases, collisions are on average more successful, and consequently, the rate of reaction increases.

An increase in the rate of reaction would see the gradient of the graph increase during the initial interval of the reaction, before plateauing sooner than the original result. The plateau, however, would remain at the same level.

Question 15 (5 marks) Five bottles labelled A, B, C, D and E contain one of the following solutions:

- Barium nitrate
- Lead(II) nitrate
- Hydrochloric acid
- Silver nitrate
- Sodium carbonate

To find out which solution was in each bottle, a student mixed solutions from pairs of bottles. The results of the tests were summarised in the table below. (NVR = no visible reaction).

	A	B	C	D	E
A	-	NVR	NVR	white precipitate	white precipitate
B	NVR	-	NVR	yellow precipitate	white precipitate
C	NVR	NVR	-	white precipitate	NVR
D	white precipitate	yellow precipitate	white precipitate	-	bubbles
E	white precipitate	white precipitate	NVR	bubbles	-

The only yellow precipitate that can be formed from these compounds is silver carbonate.

(a) Identify the five solutions.

3A

Criteria	Marks
Correctly identifies all five solutions	3
Correctly identifies four solutions	2
Correctly identifies 2 solutions	1

A	Lead(II) nitrate
B	Silver nitrate
C	Barium nitrate
D	Sodium carbonate
E	Hydrochloric acid

(b) Write a balanced chemical equation to represent the reaction between bottle D and E.

2K

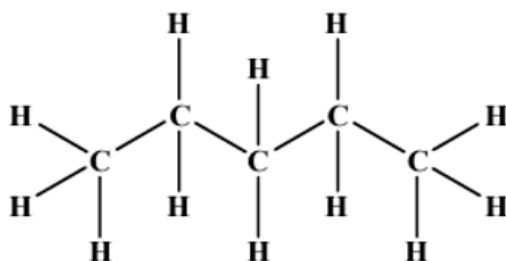
Criteria	Marks
Writes correctly balanced equation with correct states of matter	2
Provides some relevant information	1

Sample answer:



Question 16 (4 marks)

The diagram below shows the gas pentane.



a) Write a balanced chemical equation for the complete combustion of pentane. 2K

Criteria	Marks
Writes correctly balanced equation with correct states of matter	2
Provides some relevant information	1

Sample answer:



b) Given the following data, calculate the enthalpy change for this combustion reaction.

2K

Bond	Bond enthalpy (kJ mol ⁻¹)	Bond	Bond enthalpy (kJ mol ⁻¹)
C-H	414	O-H	463
C-C	346	O-O	144
C=O	804	O=O	498

Criteria	Marks
Correctly calculates heat of combustion using bond energy	2
Provides one relevant step	1

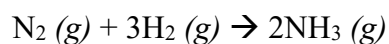
Sample answer:

$$\text{Heat of combustion} = [(4 \times 346) + (12 \times 414) + (8 \times 498)] - [(10 \times 804) + (6 \times 463)]$$

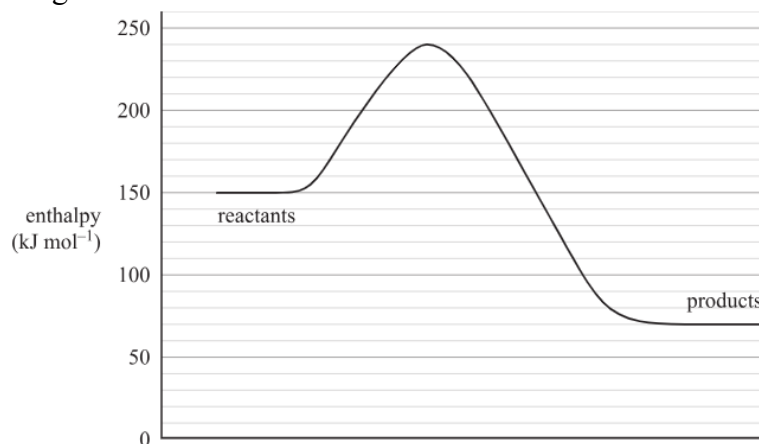
$$= -3260 \text{ kJ/mol}$$

Question 17 (7 marks)

Ammonia can be synthesised from nitrogen and hydrogen gas according to the following equation:



The energy profile diagram for this reaction is shown below:



a) What is the enthalpy change for this reaction?

1A

Criteria	Mark
Uses data from the graph to correctly determine the enthalpy for the reaction	1

Sample answer:

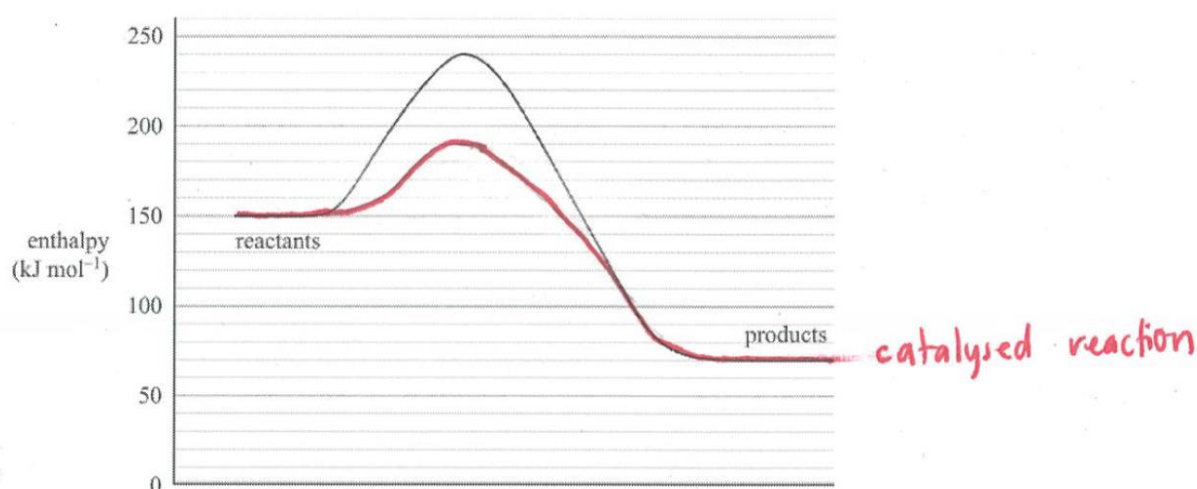
$$150 - 70$$

$$\Delta H = - 80 \text{ kJ/mol}$$

b) The reaction is catalysed by iron metal.

Draw a labelled curve on the graph above to represent the catalysed reaction.

2K



Criteria	Marks
Draw a labelled curve that correctly represents the catalysed reaction i.e. lower activation energy but same ΔH	2
Draw a curve that reasonably represents the catalysed reaction	1

c) Given the data in the table below, determine whether the uncatalysed synthesis of ammonia is spontaneous or non-spontaneous at 250°C.

4A

Substance	$\text{N}_2 (\text{g})$	$\text{H}_2 (\text{g})$	$\text{NH}_3 (\text{g})$
Standard entropy ($\text{J mol}^{-1} \text{K}^{-1}$)	192	131	193

Criteria	Marks
Correctly determines uncatalysed reaction is spontaneous by calculating Gibbs Free energy	4
Provides the main steps of the calculation	3

Provides some relevant steps of the calculation	2
Provides some relevant information	1

Sample answer:

$$\Delta S = (2 \times 193) - (192 + 3 \times 131) = -199 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$\Delta G = -80 \text{ kJ/mol} - [(273.15 + 250) \times -0.199 \text{ kJ mol}^{-1} \text{ K}^{-1}]$$

$$\Delta G = -80 - 104.10685$$

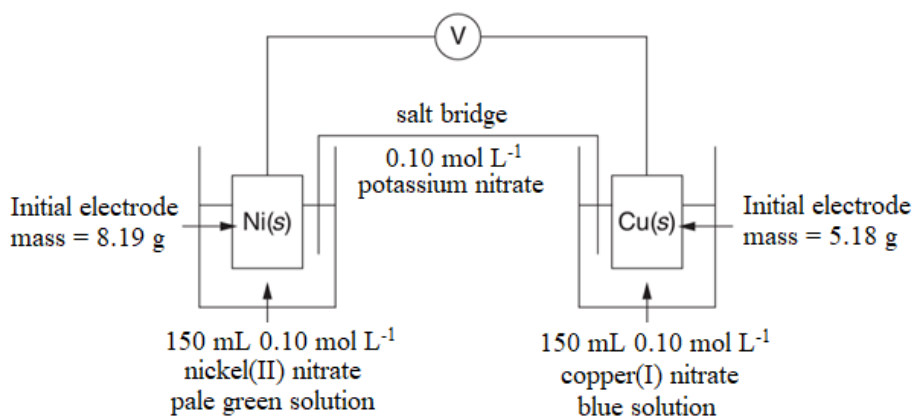
$$+24.10685 \text{ kJ/mol}$$

$$+24.1 \text{ kJ/mol (3sf)}$$

Since $\Delta G > 0$, the reaction is non-spontaneous.

Question 18 (8 marks)

A galvanic cell was constructed as shown in the diagram.



- a) Explain any colour changes observed as the reaction proceeds. Include relevant half equations. 2K

Criteria	Marks
Provides explanation for colour changes in both beakers and relevant half equations	2
Provides some relevant information	1

Sample answer:

The pale green solution becomes darker. This is because Ni is oxidised: $\text{Ni(s)} \rightarrow \text{Ni}^{2+}(\text{aq}) + 2\text{e}^-$. Ni^{2+} ions are green in colour. The darker colour is therefore a result of increased

concentration of Ni^{2+} ions in solution. The blue solution becomes lighter. This is because Cu^{+} ions are reduced: $\text{Cu}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Cu}(\text{s})$. Cu^{+} ions are blue in colour. The lighter colour is therefore a result of decreased concentration of Cu^{+} ions in solution.

- b) After some time, the electrodes were removed from the solutions, dried and reweighed. The mass of the nickel electrode had changed by 1.0 g.

Calculate the new mass of the copper electrode. Include a balanced net ionic equation for the overall cell reaction. 4K

Criteria	Marks
Correctly calculates the new mass showing working including balanced net ionic equation	4
Provides substantially correct working	3
Provides some relevant steps	2
Provides one relevant step	1

Sample answer:



$$n(\text{Ni}) = 1.00 \text{ g} / 58.69$$

$$= 0.170386778 \text{ mol}$$

$$n(\text{Cu}) = 2 \times n(\text{Ni}) = 0.0340773556 \text{ mol}$$

$$m(\text{Cu}) \text{ gained} = 0.0340773556 \text{ mol} \times 63.55 = 2.165615948 \text{ g}$$

$$\text{New mass of copper electrode} = 5.18 + 2.165615948 \text{ g} = 7.345615948 \text{ g}$$

$$= 7.3 \text{ g (2sf)}$$

- c) Calculate the final concentration of the nickel(II) nitrate solution. 2K

Criteria	Marks
Correctly calculates final concentration of Ni solution using moles of Ni lost from b)	2
Provides one relevant step	1

Sample answer:

$$C = n/V$$

$$n(\text{Initial moles of Ni}^{2+} \text{ ions in solution}) = 0.15 \text{ mol/L} \times 0.1 \text{ L} = 0.015 \text{ mol}$$

$$\text{Additional moles} = 0.170386778 \text{ mol}$$

$$\text{Final moles of Ni}^{2+} \text{ ions in solution} = 0.015 \text{ mol} + 0.170386778 \text{ mol} = 0.0320386778 \text{ mol}$$

$$\text{Final concentration of Ni}^{2+} \text{ ions} = 0.0320386778 \text{ mol} / 0.15 \text{ L} = 0.2135911853 \text{ mol/L}$$

$$= 0.21 \text{ mol/L (2sf)}$$