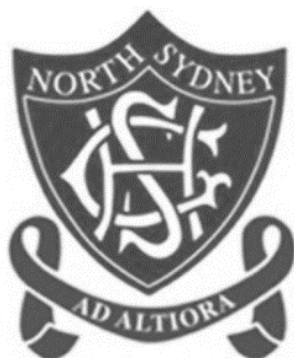


Teacher: _____

Student: _____

NORTH SYDNEY GIRLS HIGH SCHOOL



2020

Year 11 Course Examination

Chemistry

General Instructions

Reading Time – 5 minutes

Working Time – 2 hours

Write using black or blue pen

Draw diagrams using pencil

Calculators may be used

Write your teachers name and your own name at the top of this booklet AND the multiple choice answer sheet.

Total Marks – 70

Part A – 20 Marks

Attempt questions 1-20

Allow about 35 minutes for this part

Record your answer on the Multiple Choice Answer Sheet

Part B – 50 marks

Attempt questions 21-30

Allow about 1 hour and 25 minutes for this part

Write your answers in the space provided. Adequate lines have been provided.

Chemistry

Part A – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this part

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

1. Which of the following statements about gas laws is CORRECT assuming all other conditions are constant?
 - (A) Charles' Law states that gas volume is inversely proportional to gas temperature.
 - (B) Boyle's Law states that gas volume is proportional to the number of moles of gas.
 - (C) Avocado's Law states that gas volume is proportional to the number of moles of gas.
 - (D) Boyle's Law states that gas volume is inversely proportional to gas pressure.
2. Which of the following is true about all chemical reactions?
 - (A) The total moles of reactant(s) will equal the total moles of product(s).
 - (B) Atoms or ions in the reactant(s) are rearranged to form product(s).
 - (C) All atoms in the reactant(s) are converted into ions in the product(s).
 - (D) The total volume of reactant will equal the total volume of product.
3. In which of the following systems will entropy be increased?
 - (A) Converting liquid water to water vapour.
 - (B) Reacting Mg and oxygen gas to form MgO.
 - (C) Cooling Hg(l) to Hg(s).
 - (D) Producing BaSO₄ from Ba²⁺ and SO₄²⁻.
4. Which of the following metals would be most readily oxidised when added to water?
 - (A) Na
 - (B) Zn
 - (C) Ca
 - (D) Mg

Questions 5 and 6 refer to the information below.

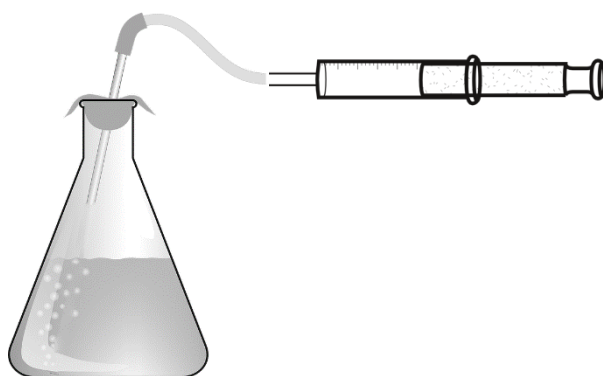
Iron metal can react with nitric acid, forming iron (III) nitrate, nitrogen monoxide gas and water vapour.

5. How many moles of nitric acid would be required to react with 3 moles of iron?
 - (A) 4
 - (B) 6
 - (C) 8
 - (D) 12

6. Which row of the table shows the species oxidised and reduced in the reaction?

	Oxidised	Reduced
(A)	Fe(s)	O in HNO ₃
(B)	Fe(s)	N in HNO ₃
(C)	H in HNO ₃	N in HNO ₃
(D)	N in HNO ₃	Fe(s)

7. The apparatus below is used to monitor the volume of gas produced from a conical flask in which zinc reacts with dilute nitric acid.



How will the rate of reaction change if a piece of zinc metal is added to nitric acid at different temperatures?

- (A) As the temperature of the acid increases, the rate of reaction increases.
 - (B) As the temperature of the acid increases, the rate of reaction decreases.
 - (C) The reaction will only occur at very high temperatures.
 - (D) The rate of reaction is maximised at the ideal temperature. If the temperature is increased or decreased, the rate of reaction will decrease.
8. A match is used to light a candle wick. The candle is then permitted to burn until half the wax has been combusted. Which of the following describes the energy involved in the reaction?
- (A) $\Delta H > 0$, $E_a > 0$
 - (B) $\Delta H < 0$, $E_a > 0$
 - (C) $\Delta H > 0$, $E_a < 0$
 - (D) $\Delta H < 0$, $E_a < 0$
9. Which of the following chemical bonds is the most polar?
- (A) S-H
 - (B) O-H
 - (C) C-H
 - (D) F-F

10. A student wished to set up a simple galvanic cell for an experiment. Which of the following cathode/anode combinations would produce a current?

	Anode	Cathode
(A)	Manganese	Magnesium
(B)	Iron	Zinc
(C)	Nickel	Copper
(D)	Silver	Copper

11. A student heats two different substances of equal mass and surface area using the same experimental conditions. She discovers that Substance 1 reaches a higher temperature than Substance 2. What is the most likely reason for this?

- (A) Substance 1 has a higher specific heat capacity than Substance 2
- (B) Substance 2 has a higher specific heat capacity than Substance 1
- (C) Substance 1 has a higher thermal conductivity than Substance 2
- (D) Substance 2 has a higher thermal conductivity than Substance 1

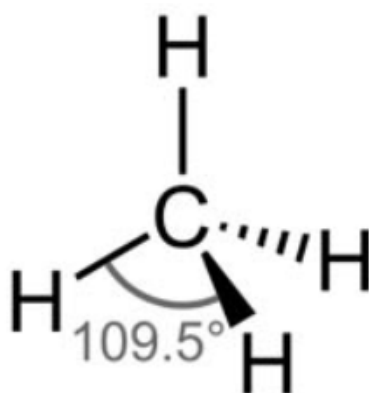
12. What is the number of electrons in the outer shell of a Mg^{2+} ion?

- (A) 2
- (B) 6
- (C) 8
- (D) 18

13. 42.6 g of chlorine gas reacts with 10.8 g of an element "X", to form the chloride of X, with the formula XCl_3 . What is the molar mass of element X?

- (A) 10.81 g/mol
- (B) 26.98 g/mol
- (C) 69.72 g/mol
- (D) 114.82 g/mol

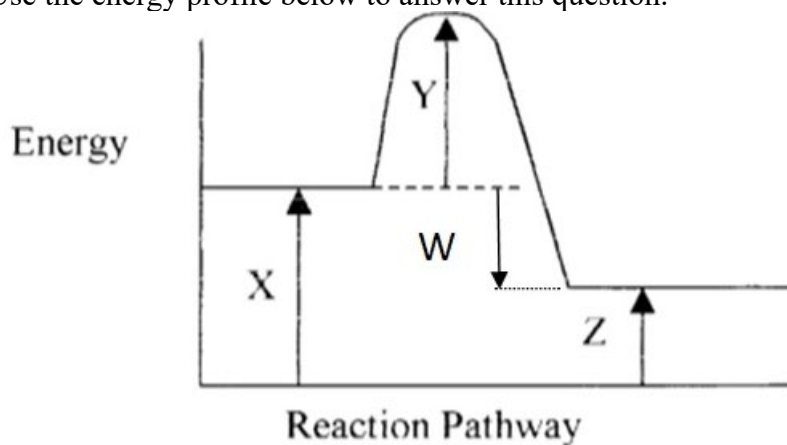
14. A molecule of methane has a tetrahedral molecular shape.



Which of the following substances also has a tetrahedral molecular shape?

- (A) Ammonia
- (B) Water
- (C) Phosphorus pentachloride
- (D) Ammonium

15. The formula of potassium permanganate is KMnO_4 . Based on this information, what is the charge on the permanganate ion?
- (A) +1
(B) -1
(C) +2
(D) -2
16. Which of the following statements is CORRECT?
- (A) Dipole-dipole bonds are stronger than hydrogen bonds.
(B) Dispersion forces, hydrogen bonds, dipole-dipole bonds and covalent bonds are examples of intermolecular forces.
(C) Dispersion forces are strong intermolecular forces.
(D) Dipole-dipole bonds are stronger than dispersion forces.
17. Which of the following conducts electricity in the molten and solid states?
- (A) Fructose
(B) Lithium chloride
(C) Boron
(D) Cobalt
18. A silver polish contains methylated spirits at 30.5% v/v. What volume of methylated spirits would be found in a 250 mL can?
- (A) 76.3 mL
(B) 80.2 mL
(C) 30.5 mL
(D) 30.5 g
19. Use the energy profile below to answer this question.



Which letter represents the activation energy for the reaction?

- (A) X
(B) Y
(C) W
(D) Z
20. In which of the following reactions is there a decrease in entropy?
- (A) $\text{CaCO}_{3(s)} \rightarrow \text{CaO}_{(s)} + \text{CO}_{2(g)}$
(B) $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$
(C) $\text{C}_2\text{H}_5\text{OH}_{(l)} + 3\text{O}_{2(g)} \rightarrow 2\text{CO}_{2(g)} + 3\text{H}_2\text{O}_{(g)}$
(D) $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$

Chemistry

Part B – 50 marks

Attempt Questions 21-30

Allow about 1 hour and 25 minutes for this part

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Extra writing booklets are available. If you use extra booklets, clearly indicate which question you are answering.
- Show all relevant working in questions involving calculations.

Question 21 (3 marks)

Complete the table below using IUPAC conventions.

Name	Formula
Iron (III) chloride	
	SO ₂
Potassium carbonate	

Question 22 (7 marks)

The table below gives the properties of three pure substances: P, Q and R.

	P	Q	R
Appearance	Red solid	Grey solid	White solid
Melting point (°C)	1040	763	880
Solubility in water	insoluble	insoluble	soluble
Electrical conductivity when solid	does not conduct	conducts	does not conduct
Electrical conductivity when molten	does not conduct	conducts	conducts but decomposes

- (a) Explain why R conducts electricity when molten, but not when solid.

2

- (b) Suggest one possible reason why Q does not decompose.

1

- (c) A student claimed that P must be a covalent network substance. Justify this claim using the data and your knowledge of structure and bonding. **4**

Question 23 (3 marks)

3

A compound with a mass of 4.0 g containing C, H and O was combusted to produce 3.92 g of CO₂ and 0.8 g of H₂O. Calculate the mass of oxygen in the compound.

QUESTION 24 BEGINS ON THE NEXT PAGE

Question 24 (5 marks)

- (a) A weather balloon is filled with helium at 0°C and $1.00 \times 10^5 \text{ Pa}$. By what factor will its volume change when it passes through a region where the temperature is -85°C and the pressure is $1.00 \times 10^4 \text{ Pa}$? **3**

- (b) The same weather balloon has a volume of 5000 L at ground level and contains 300 moles of helium at 0°C . Calculate the pressure exerted by the gas. **2**

Question 25 (5 marks)

A sample of solid magnesium with a mass of 10.45 g was reacted with 250 mL of 1.00 mol/L copper (II) sulfate solution to produce an aqueous salt and a metal.

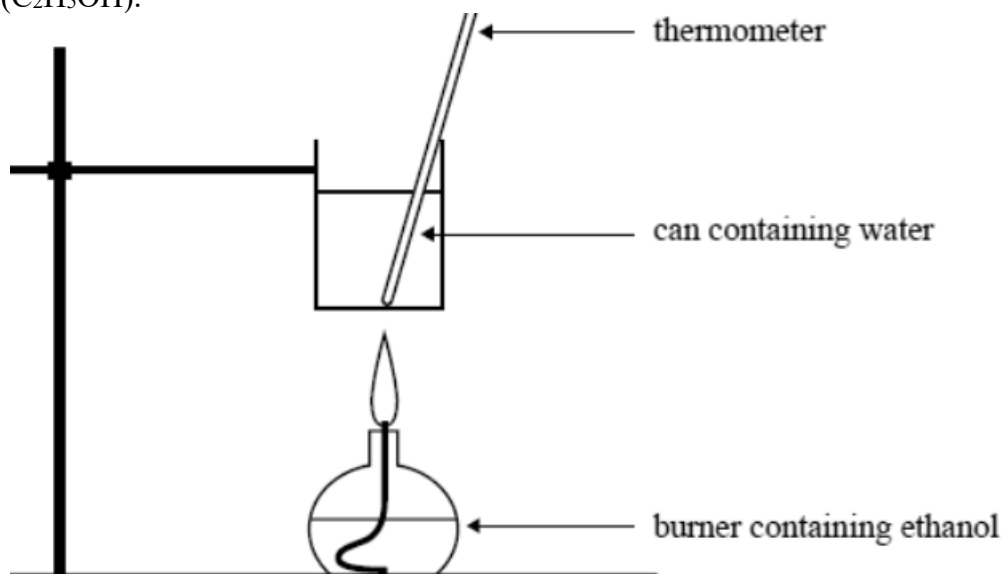
- (a) Write a balanced chemical equation for the above reaction. **1**

- (b) How many moles of Mg(s) would be present at the end of the reaction? **2**

- (c) Calculate the mass of the salt produced by the reaction. **2**

Question 26 (6 marks)

A chemistry student set up the following equipment to measure the enthalpy of combustion of ethanol ($\text{C}_2\text{H}_5\text{OH}$).



The student recorded the following results.

	Trial 1	Trial 2	Trial 3
Mass of ethanol burned (g)	0.32	0.28	0.33
Increase in temperature ($^{\circ}\text{C}$)	5.5	5.6	5.5
Heat absorbed by water, q (J)			

(a) The student heated 100 mL of water in each test. Complete the table by calculating the value of q for each test. 1

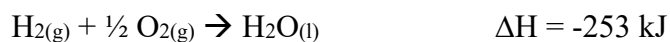
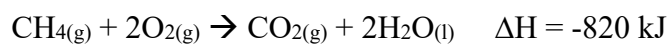
(b) Calculate the average number of moles of ethanol burned. 1

(c) Calculate the experimental enthalpy of combustion for ethanol in kJ/mol. 2

- (d) The student's textbook stated the enthalpy of combustion for ethanol was -1367 kJ/mol. 2
Explain ONE reason why the student's experimental value may have been lower than expected.

Question 27 (2 marks)

The combustion reactions of methane, carbon and hydrogen are provided below.

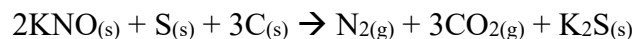


Calculate the enthalpy change when one mole of methane is formed from carbon and hydrogen. Show all working.

QUESTION 28 BEGINS ON THE NEXT PAGE

Question 28 (6 marks)

Gun powder, a mixture of saltpetre, sulfur and charcoal, explodes according to the equation:



Formula	ΔS° ($\text{J K}^{-1} \text{mol}^{-1}$)	ΔH_f° (kJ mol^{-1})
$\text{KNO}_{(\text{s})}$	138	-498
$\text{S}_{(\text{s})}$	30	0
$\text{C}_{(\text{s})}$	5	0
$\text{N}_{2(\text{g})}$	194	0
$\text{CO}_{2(\text{g})}$	216	-393
$\text{K}_2\text{S}_{(\text{s})}$	118	-375

- (a) Calculate the change in entropy for the reaction using the information in the table above. The reaction is carried out at a constant temperature of 25°C .

2

- (b) Calculate the Gibbs' Free Energy to determine if the reaction is spontaneous at 25°C .

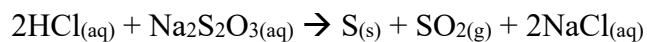
2

- (c) Would the reaction be spontaneous at 0°C ? Justify your answer.

2

Question 29 (8 marks)

A student investigated the rate of the reaction between hydrochloric acid and sodium thiosulfate by adding excess acid to varying concentrations of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$). The equation for the reaction is:



The time for the reaction to complete was measured using a stopwatch and recorded below.

Concentration of $\text{Na}_2\text{S}_2\text{O}_3$ (mol L^{-1})	Reaction time (s)
0.03	160
0.06	60
0.09	35
0.12	27
0.15	23

(a) Identify the independent variable in this experiment.

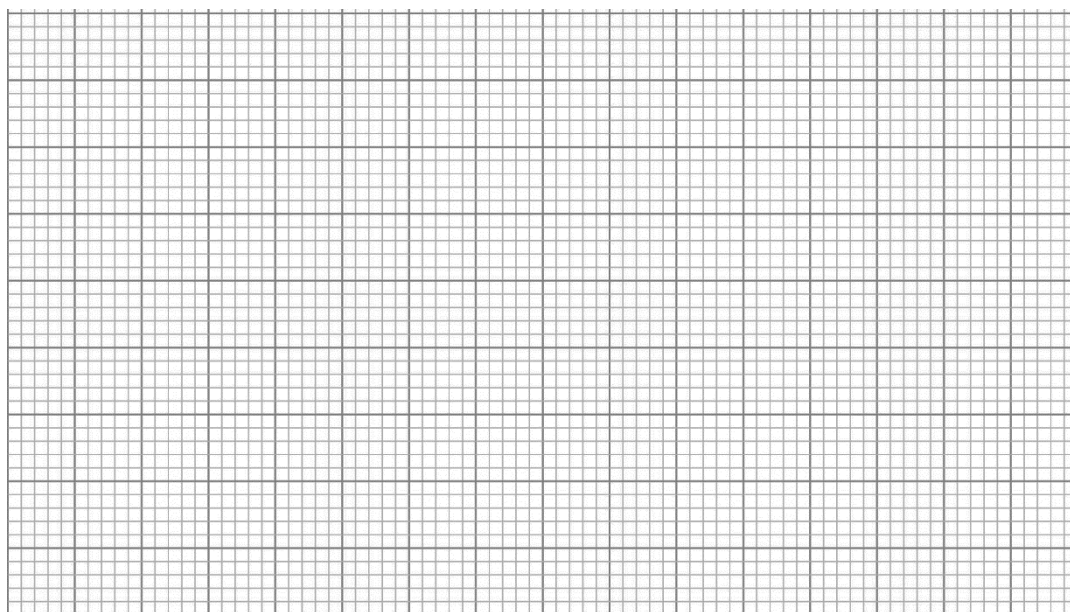
1

(b) Identify one variable that should be controlled in this experiment.

1

(c) Use the data to produce a graph on the grid below.

3



(d) Explain the shape of the graph using your understanding of collision theory.

3

Question 30 (5 marks)

Ammonium nitrate ($\text{NH}_4\text{NO}_3(\text{s})$) is often used as an explosive in quarrying iron ore in Western Australia. When heated gently it decomposes to form dinitrogen monoxide and gaseous water. When it explodes it produces nitrogen gas, oxygen gas and gaseous water. The enthalpies of formation for several relevant compounds are given in the table below.

Substance	ΔH_f° (kJ mol ⁻¹)
$\text{NH}_4\text{NO}_3(\text{s})$	-360
$\text{H}_2\text{O}(\text{g})$	-245
$\text{N}_2\text{O}(\text{g})$	+ 80

(a) Calculate the enthalpy change that occurs when one mole of ammonium nitrate is heated gently.

2

(b) Calculate the amount of energy released when 1 kg of ammonium nitrate explodes.

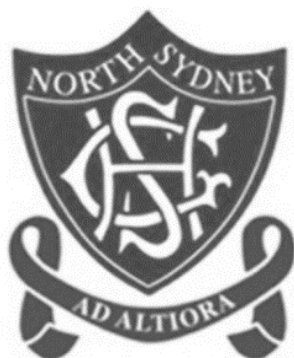
3

END OF EXAM

Teacher: _____

Student: _____

NORTH SYDNEY GIRLS HIGH SCHOOL



2020

Year 11 Course Examination

Chemistry

General Instructions

Reading Time – 5 minutes

Working Time – 2 hours

Write using black or blue pen

Draw diagrams using pencil

Calculators may be used

Write your teachers name and your own name at the top of this booklet AND the multiple choice answer sheet.

Total Marks – 70

Part A – 20 Marks

Attempt questions 1-20

Allow about 35 minutes for this part

Record your answer on the Multiple Choice Answer Sheet

Part B – 50 marks

Attempt questions 21-30

Allow about 1 hour and 25 minutes for this part

Write your answers in the space provided. Adequate lines have been provided.

Chemistry

Part A – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this part

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

- Which of the following statements about gas laws is CORRECT assuming all other conditions are constant?
 - Charles' Law states that gas volume is inversely proportional to gas temperature.
 - Boyle's Law states that gas volume is proportional to the number of moles of gas.
 - Avocado's Law states that gas volume is proportional to the number of moles of gas.
 - Boyle's Law states that gas volume is inversely proportional to gas pressure.**
- Which of the following is true about all chemical reactions?
 - The total moles of reactant(s) will equal the total moles of product(s).
 - Atoms or ions in the reactant(s) are rearranged to form product(s).**
 - All atoms in the reactant(s) are converted into ions in the product(s).
 - The total volume of reactant will equal the total volume of product.
- In which of the following systems will entropy be increased?
 - Converting liquid water to water vapour.**
 - Reacting Mg and oxygen gas to form MgO.
 - Cooling Hg(l) to Hg(s).
 - Producing BaSO₄ from Ba²⁺ and SO₄²⁻.
- Which of the following metals would be most readily oxidised when added to water?
 - Na
 - Zn
 - Ca**
 - Mg

Questions 5 and 6 refer to the information below.

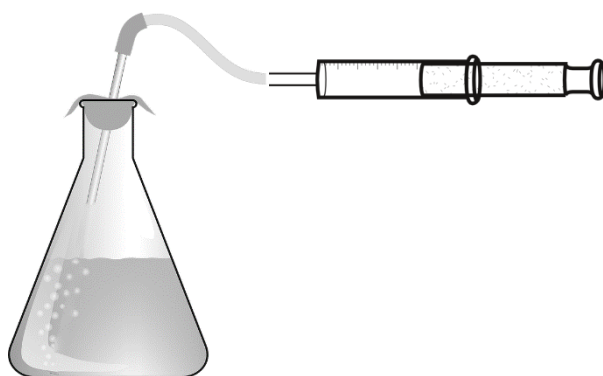
Iron metal can react with nitric acid, forming iron (III) nitrate, nitrogen monoxide gas and water vapour.

- How many moles of nitric acid would be required to react with 3 moles of iron?
 - 4
 - 6
 - 8
 - 12**

6. Which row of the table shows the species oxidised and reduced in the reaction?

	Oxidised	Reduced
(A)	Fe _(s)	O in HNO ₃
(B)	Fe_(s)	N in HNO₃
(C)	H in HNO ₃	N in HNO ₃
(D)	N in HNO ₃	Fe _(s)

7. The apparatus below is used to monitor the volume of gas produced from a conical flask in which zinc reacts with dilute nitric acid.



How will the rate of reaction change if a piece of zinc metal is added to nitric acid at different temperatures?

- (A) **As the temperature of the acid increases, the rate of reaction increases.**
 (B) As the temperature of the acid increases, the rate of reaction decreases.
 (C) The reaction will only occur at very high temperatures.
 (D) The rate of reaction is maximised at the ideal temperature. If the temperature is increased or decreased, the rate of reaction will decrease.
8. A match is used to light a candle wick. The candle is then permitted to burn until half the wax has been combusted. Which of the following describes the energy involved in the reaction?
- (A) $\Delta H > 0$, $E_a > 0$
 (B) **$\Delta H < 0$, $E_a > 0$**
 (C) $\Delta H > 0$, $E_a < 0$
 (D) $\Delta H < 0$, $E_a < 0$
9. Which of the following chemical bonds is the most polar?
- (A) S-H
 (B) **O-H**
 (C) C-H
 (D) F-F

10. A student wished to set up a simple galvanic cell for an experiment. Which of the following cathode/anode combinations would produce a current?

	Anode	Cathode
(A)	Manganese	Magnesium
(B)	Iron	Zinc
(C)	Nickel	Copper
(D)	Silver	Copper

11. A student heats two different substances of equal mass and surface area using the same experimental conditions. She discovers that Substance 1 reaches a higher temperature than Substance 2. What is the most likely reason for this?

- (A) Substance 1 has a higher specific heat capacity than Substance 2
(B) **Substance 2 has a higher specific heat capacity than Substance 1**
(C) Substance 1 has a higher thermal conductivity than Substance 2
(D) Substance 2 has a higher thermal conductivity than Substance 1

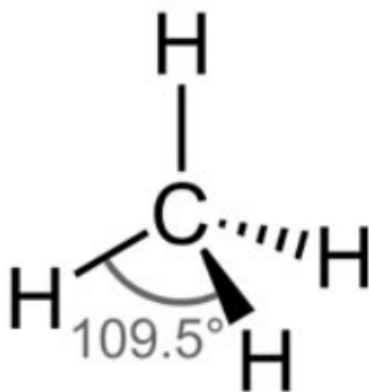
12. What is the number of electrons in the outer shell of a Mg^{2+} ion?

- (A) 2
(B) 6
(C) **8**
(D) 18

13. 42.6 g of chlorine gas reacts with 10.8 g of an element "X", to form the chloride of X, with the formula XCl_3 . What is the molar mass of element X?

- (A) 10.81 g/mol
(B) **26.98 g/mol**
(C) 69.72 g/mol
(D) 114.82 g/mol

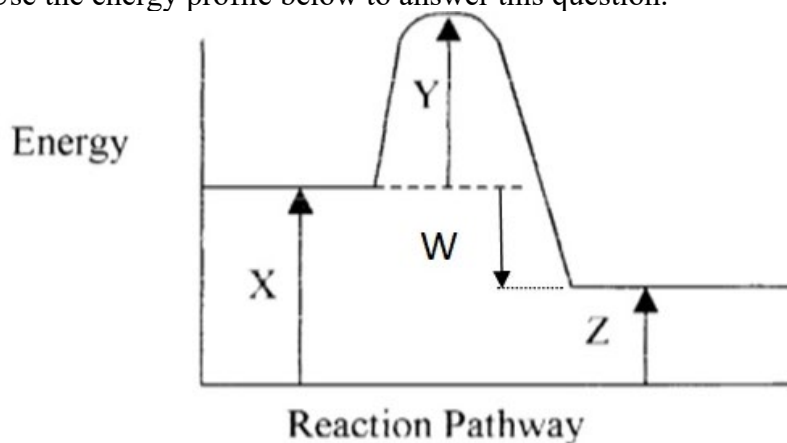
14. A molecule of methane has a tetrahedral molecular shape.



Which of the following substances also has a tetrahedral molecular shape?

- (A) Ammonia
(B) Water
(C) Phosphorus pentachloride
(D) **Ammonium**

15. The formula of potassium permanganate is KMnO_4 . Based on this information, what is the charge on the permanganate ion?
- (A) +1
(B) -1
 (C) +2
 (D) -2
16. Which of the following statements is CORRECT?
- (A) Dipole-dipole bonds are stronger than hydrogen bonds.
 (B) Dispersion forces, hydrogen bonds, dipole-dipole bonds and covalent bonds are examples of intermolecular forces.
 (C) Dispersion forces are strong intermolecular forces.
(D) Dipole-dipole bonds are stronger than dispersion forces.
17. Which of the following conducts electricity in the molten and solid states?
- (A) Fructose
 (B) Lithium chloride
 (C) Boron
(D) Cobalt
18. A silver polish contains methylated spirits at 30.5% v/v. What volume of methylated spirits would be found in a 250 mL can?
- (A) 76.3 mL**
 (B) 80.2 mL
 (C) 30.5 mL
 (D) 30.5 g
19. Use the energy profile below to answer this question.



Which letter represents the activation energy for the reaction?

- (A) X
(B) Y
 (C) W
 (D) Z
20. In which of the following reactions is there a decrease in entropy?
- (A) $\text{CaCO}_{3(s)} \rightarrow \text{CaO}_{(s)} + \text{CO}_{2(g)}$
(B) $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$
 (C) $\text{C}_2\text{H}_5\text{OH}_{(l)} + 3\text{O}_{2(g)} \rightarrow 2\text{CO}_{2(g)} + 3\text{H}_2\text{O}_{(g)}$
 (D) $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$

Chemistry

Part B – 50 marks

Attempt Questions 21-30

Allow about 1 hour and 25 minutes for this part

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Extra writing booklets are available. If you use extra booklets, clearly indicate which question you are answering.
- Show all relevant working in questions involving calculations.

Question 21 (3 marks)

Complete the table below using IUPAC conventions.

Name	Formula
Iron (III) chloride	FeCl_3
Sulfur dioxide	SO_2
Potassium carbonate	K_2CO_3

Question 22 (7 marks)

The table below gives the properties of three pure substances: P, Q and R.

	P	Q	R
Appearance	Red solid	Grey solid	White solid
Melting point ($^{\circ}\text{C}$)	1040	763	880
Solubility in water	insoluble	insoluble	soluble
Electrical conductivity when solid	does not conduct	conducts	does not conduct
Electrical conductivity when molten	does not conduct	conducts	conducts but decomposes

- (a) Explain why R conducts electricity when molten, but not when solid.

R is an ionic compound and won't conduct when solid as the ions that make up the lattice are held tightly together by electrostatic forces.

When molten the ionic bonds are not as strong so the charged ions are able to move i.e. they will be able to conduct electricity.

- (b) Suggest one possible reason why Q does not decompose.

Q is an element.

- (c) A student claimed that P must be a covalent network substance. Justify this claim using the data and your knowledge of structure and bonding. 4
Needed to have the following criteria for full marks.

Very high melting point, non-conductor, solid at room temperature and insoluble.

In a covalent network substance the atoms are held together by very strong covalent bonds which creates a rigid lattice (hence a high melting point and it will be solid at room temperature). Because all of the electrons are involved in forming the covalent bond there are no 'free' electrons to conduct electricity (hence it is a non-conductor).

The strong bonds and the fact that the lattice won't form ions to produce an ion-dipole with water means that it will not dissolve in water (hence it is insoluble).

Question 23 (3 marks) 3

A compound with a mass of 4.0 g containing C, H and O was combusted to produce 3.92 g of CO₂ and 0.8 g of H₂O. Calculate the mass of oxygen in the compound.

Determine no. moles of CO₂ and H₂O - 1mk

Using method 1

Determine mass of C and H present in compound 1mk

Subtract from mass of compound 1mk

Using Method 2

Determine total mass of oxygen in products 1mk

Subtract excess mass of products (relative to original compound) from total mass of oxygen in products. 1 mk

Method 1

Mass of C in compound = 1.069g

Mass of H in compound = 0.089g

Mass of O in compound = 4.0 - 1.069 - 0.089 = 2.84g

Method 2

Mass of O in products = 3.56g

Total product mass is 0.72g more than mass of original compound, this is due to additional O₂ needed for combustion.

Mass of O in compound = 3.56 - 0.72 = 2.84g

Question 24 (5 marks)

- (a) A weather balloon is filled with helium at 0°C and 1.00×10^5 Pa. By what factor will its volume change when it passes through a region where the temperature is -85°C and the pressure is 1.00×10^4 Pa? 3

1 mark – substitution into a correct equation OR derives below expression

2 marks – correct working with minor error

3 marks – correct working

$$V_2/V_1 = P_1 T_2 / P_2 T_1 = \frac{(1.00 \times 10^5 \text{ Pa})(188.15 \text{ K})}{(1.00 \times 10^4 \text{ Pa})(273.15 \text{ K})} = 6.89 = 7$$

- (b) The same weather balloon has a volume of 5000 L at ground level and contains 300 moles of helium at 0°C. Calculate the pressure exerted by the gas. 2

1 mark – correct working

2 marks - correct answer with correct units

$$P = nRT/V = 300 \text{ mol} \times 8.3145 \times 273.15 \text{ K} / 5000 \text{ L} = 136 \text{ kPa}$$

Question 25 (5 marks)

A sample of solid magnesium with a mass of 10.45 g was reacted with 250 mL of 1.00 mol/L copper (II) sulfate solution to produce an aqueous salt and a metal.

- (a) Write a balanced chemical equation for the above reaction. 1



- (b) How many moles of Mg(s) would be present at the end of the reaction? 2

1 mark – finds moles of Mg (initial) and/or moles of copper sulfate

2 marks – correct working

$$\text{mol Mg (final)} = (10.45 \text{ g} / 24.3 \text{ g/mol}) - (0.250 \text{ L} \times 1.00 \text{ mol/L}) = 0.180 \text{ mol}$$

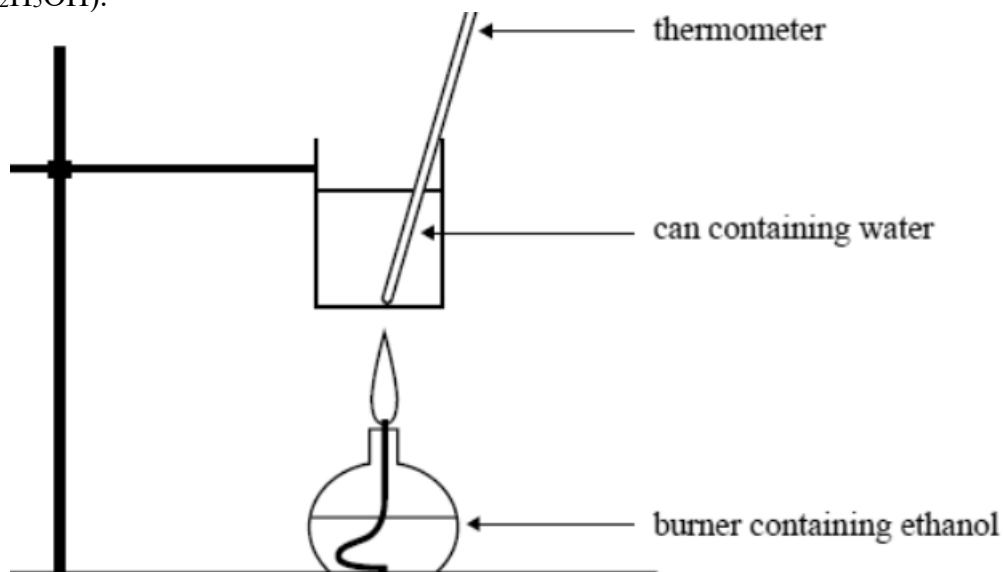
- (c) Calculate the mass of the salt produced by the reaction. 2

2 marks – correct working AND sig figs (3)

$$m = 0.250 \text{ mol} \times (24.3 + 32.07 + 4(16)) \text{ g/mol} = 30.0925 = 30.1 \text{ g}$$

Question 26 (6 marks)

A chemistry student set up the following equipment to measure the enthalpy of combustion of ethanol ($\text{C}_2\text{H}_5\text{OH}$).



The student recorded the following results.

	Trial 1	Trial 2	Trial 3
Mass of ethanol burned (g)	0.32	0.28	0.33
Increase in temperature ($^{\circ}\text{C}$)	5.5	5.6	5.5
Heat absorbed by water, q (J)	2,299	2,341	2,299

- (a) The student heated 100 mL of water in each test. Complete the table by calculating the value of q for each test. 1

- (b) Calculate the average number of moles of ethanol burned. 1

$$\text{Average no. moles} = (0.32 + 0.28 + 0.33)/3 \times 46 = 0.0067$$

- (c) Calculate the experimental enthalpy of combustion for ethanol in kJ/mol. 2

$$\Delta H = -q / \text{no. moles} = -2,313 / 0.0067 \quad 1\text{mk}$$

$$= -345 \text{ kJ/mol} \quad 1\text{mk NB negative sign must be present}$$

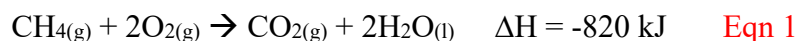
- (d) The student's textbook stated the enthalpy of combustion for ethanol was -1367 kJ/mol. Explain ONE reason why the student's experimental value may have been lower than expected. 2

State Energy/Heat lost to environment 1 mk

Explain that water absorbs less energy hence lower ΔT 1 mk

Question 27 (2 marks)

The combustion reactions of methane, carbon and hydrogen are provided below.



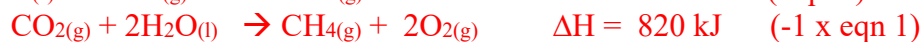
Calculate the enthalpy change when one mole of methane is formed from carbon and hydrogen. Show all working.

1marks – correct working with error

2 marks – correct working

Equation for formation of methane is: $\text{C}(\text{s}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$

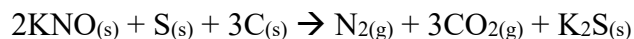
This can be achieved by :



Adding these equations gives $\Delta H = -78 \text{ kJ}$

Question 28 (6 marks)

Gun powder, a mixture of saltpetre, sulfur and charcoal, explodes according to the equation:



Formula	ΔS° ($\text{J K}^{-1} \text{mol}^{-1}$)	ΔH_f° (kJ mol^{-1})
$\text{KNO}_{(s)}$	138	-498
$\text{S}_{(s)}$	30	0
$\text{C}_{(s)}$	5	0
$\text{N}_{2(g)}$	194	0
$\text{CO}_{2(g)}$	216	-393
$\text{K}_2\text{S}_{(s)}$	118	-375

- (a) Calculate the change in entropy for the reaction using the information in the table above. The reaction is carried out at a constant temperature of 25°C. 2

$$\begin{aligned}\Delta S &= [(194) + 3(216) + (118)] - [2(138) + (30) + 3(5)] \\ &= 960 - 321 \\ &= 639 \text{ J K}^{-1} \text{mol}^{-1}\end{aligned}$$

2 marks correct working and answer

1 mark correct working with error

Note: if calculated ΔH – no marks

- (b) Calculate the Gibbs' Free Energy to determine if the reaction is spontaneous at 25°C. 2

$$\begin{aligned}\Delta H &= [(0) + 3(-393) + (-375)] - [2(-498) + (0) + 3(0)] \\ &= -558 \text{ kJ mol}^{-1} \\ \Delta S &= 0.639 \text{ kJ K}^{-1} \text{mol}^{-1} \\ \Delta G &= \Delta H - T\Delta S \\ &= (-558) - (298.15)(0.639) \\ &= -748.517 \text{ kJ mol}^{-1} \\ &= -749 \text{ kJ mol}^{-1} \\ &< 0 \quad \therefore \text{spontaneous at } 25^\circ\text{C}\end{aligned}$$

1 mark correct ΔH calculation

1 mark correct Gibbs' Free Energy calculation and 'spontaneous' (needed to determine spontaneity to achieve this mark)

Note: quite a few students did not convert ΔS before calculating ΔG .

In future, make sure you state that $\Delta G < 0$ and then therefore spontaneous.

(c) Would the reaction be spontaneous at 0°C? Justify your answer.

2

$$\Delta G = (-558) - (273)(0.639)$$
$$= -732.44$$
$$< 0 \quad \therefore \text{spontaneous}$$

Note: convert to kelvin!

OR

$\Delta S > 0$ $\Delta H < 0$ therefore

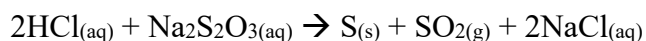
$\Delta G < 0$ Spontaneous at all T (needed to include this justification to achieve 2 marks)

2 marks – correct answer and correct justification

1 mark – correct working with error

Question 29 (8 marks)

A student investigated the rate of the reaction between hydrochloric acid and sodium thiosulfate by adding excess acid to varying concentrations of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$). The equation for the reaction is:



The time for the reaction to complete was measured using a stopwatch and recorded below.

Concentration of $\text{Na}_2\text{S}_2\text{O}_3$ (mol L^{-1})	Reaction time (s)
0.03	160
0.06	60
0.09	35
0.12	27
0.15	23

(a) Identify the independent variable in this experiment.

1

Concentration of sodium thiosulfate

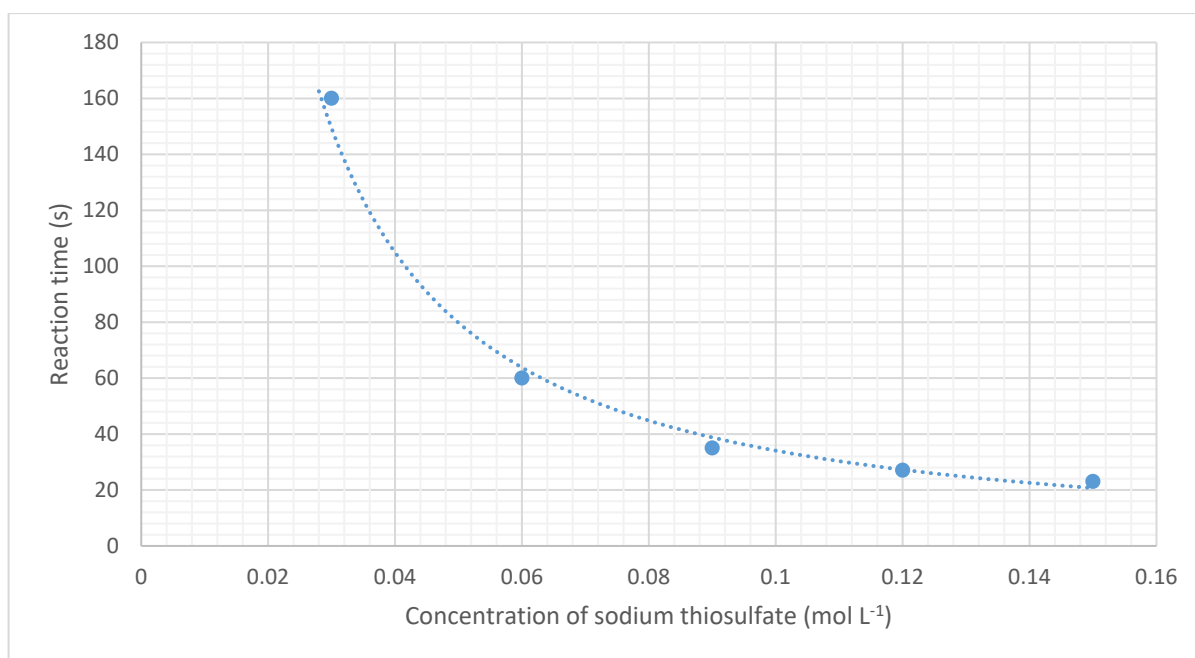
(b) Identify one variable that should be controlled in this experiment.

1

Any reasonable variable accepted. "Amount" is not specific enough, nor the name of an item eg "the stopwatch".

(c) Use the data to produce a graph on the grid below.

3



1 – scale

1 – line of best fit

½ - data points

½ - axis labels

(d) Explain the shape of the graph using your understanding of collision theory.

3

1 mark – correctly outlines the application of collision theory to increased concentration

1 mark – explains how this concept produces the graph shape (eg: “because”, “therefore”, “accounts for”)

1 mark – correctly expresses relationship between reaction rate and reaction time (ie no confusion between the two)

Sample answer:

It can be seen in the graph that reaction time decreases non-linearly as the concentration of sodium thiosulfate increases. This can be accounted for using collision theory. A reaction occurs when reactant particles collide with sufficient energy and in the correct orientation. Increasing the concentration of sodium thiosulfate increases the number of reactant particles in a given volume, which increases the number of collisions between reactant particles occurring within a given time frame. This increases the rate of reaction which can be seen in the decreasing reaction time that occurs in the graph.

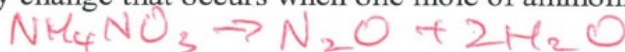
Note: some students addressed the plateau in the graph. This is good, but was not required by the marking scheme.

Question 30 (5 marks)

Ammonium nitrate ($\text{NH}_4\text{NO}_3(\text{s})$) is often used as an explosive in quarrying iron ore in Western Australia. When heated gently it decomposes to form dinitrogen monoxide and gaseous water. When it explodes it produces nitrogen gas, oxygen gas and gaseous water. The enthalpies of formation for several relevant compounds are given in the table below.

Substance	ΔH_f° (kJ mol ⁻¹)
$\text{NH}_4\text{NO}_3(\text{s})$	-360
$\text{H}_2\text{O}(\text{g})$	-245
$\text{N}_2\text{O}(\text{g})$	+ 80

- (a) Calculate the enthalpy change that occurs when one mole of ammonium nitrate is heated gently. 2



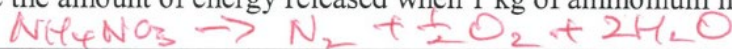
$$\Delta H = [(80) + 2(-245)] - [(-360)]$$

$$= -50 \text{ kJ mol}^{-1}$$

2 marks correct working and answer

1 mark – correct working with error

- (b) Calculate the amount of energy released when 1 kg of ammonium nitrate explodes. 3



$$\Delta H = [(0) + (0) + 2(-245)] - [(-360)]$$

$$= -130 \text{ kJ mol}^{-1}$$

$$n(\text{NH}_4\text{NO}_3) = 1000 \div (14.01 \times 2 + 1.008 \times 4 + 16 \times 3)$$

$$= 12.491... \text{ mol}$$

$$q = -\Delta H \times n = 130 \times 12.491...$$

$$= 16237 \text{ kJ}$$

1 mark correct ΔH calculation

1 mark correct $n(\text{ammonium nitrate})$ calculation

1 mark correct q calculation

Note: before calculating q (multiplying ΔH by n), you need to make sure your calculated ΔH was per 1 mole of substance in question.

Quite a few students did not balance their equations for both parts or used the incorrect equation for part b – when ammonium nitrate explodes NOT heated gently.

END OF EXAM