Student Name:

Class:

SYDNEY BOYS HIGH SCHOOL

YEAR 11 CHEMISTRY

ASSESSMENT TASK 3

FINAL EXAMINATION

SEPTEMBER 2022

INSTRUCTIONS

- Reading time – 5 minutes.
- Working time – 2 hours.
- Write using black pen.
- Draw diagrams using pencil.
- For questions in Section II, show all relevant working in questions involving calculations.
- NESA approved calculators may be used.

Total marks: 75

Section I – Multiple Choice Questions (20 marks)

- Attempt questions 1 – 20.
- Use Multiple Choice Answer Grid Provided.
- Allow about 35 minutes for this section.

Section II – 55 marks

- Attempt questions 21 – 31.
- Answer all questions in this booklet.
- Allow about 1 hour and 25 minutes for this section.

Section I – Multiple Choice Questions.

20 Marks.

Attempt Questions 1 – 20.

Use the Multiple Choice Answer Grid provided.

Clearly mark one answer only per question.

Allow about 35 minutes for this section.

Questions 1 to 3 refer to the following information

A class of chemistry students designed the following experiment to investigate the relationship between the concentration of a solution in a reaction and how fast a product is produced.

Different concentrations of hydrochloric acid were added to a standardised sodium thiosulfate solution. The reaction produced solid sulfur, as shown in the equation below.

$$2HCl_{(aq)} + Na_2S_2O_{3(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(g)} + H_2O_{(l)} + S_{(s)}$$

A piece of paper with a cross was placed beneath the conical flask containing the reaction mixture. As soon as the reactants were added and mixed, the conical flask was placed on top of the cross, and the time taken for the cross to disappear due to the formation of the sulfur was timed with a stopwatch.

1. Which one needs to be a *controlled* variable for student's investigations?

(A) The time taken for the cross to disappear.

(B) The total volume of liquids in the conical flask.

(C) The rate of the reaction.

(D) The mass of sulfur produced.

2. The type of data collected and the source of the data in the student's investigation is best characterised as:

(A) qualitative data; primary source.

(B) qualitative data; secondary source.

(C) quantitative data; primary source.

(D) quantitative data; secondary source.

3. While conducting the investigation, a group of students decided to take turns observing and timing when the cross disappeared.

Which of the following is a correct statement concerning this choice?

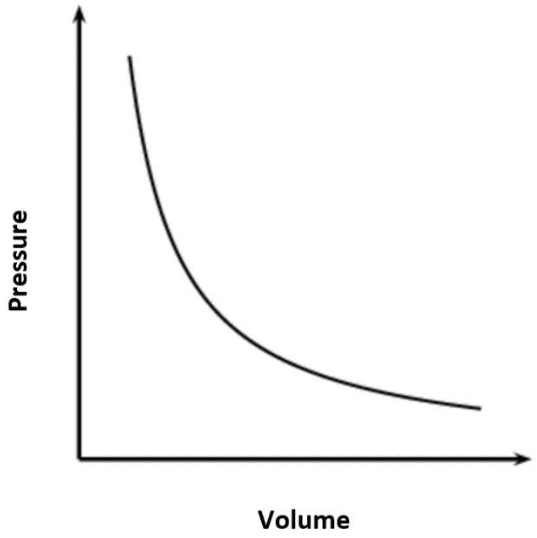
(A) It improves the methodology as it increases the efficiency of data collection.

(B) It makes the method less valid as it introduces more systematic errors.

(C) It improves the methodology because one person may take the readings more accurately.

(D) It is a poor decision as it is likely to decrease the reproducibility of the data collected.

4. The following graph shows a relationship between ideal gas pressure and its volume if temperature is kept constant.
Identify which gas law does this graph identify?



(A) Boyle's Law
(B) Charles Law
(C) Avogadro's Law
(D) Gay-Lussac's Law

5. An element X has the following properties:

- It is a good reducing agent.
- It reacts readily with water to produce molecular hydrogen and a solution containing a colourless ion, X^{2+}
- It is naturally strongly radioactive.

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

(A) Ra

(B) Cs

(C) Ca

(D) Po

6. Metallic crystal lattices have high melting and boiling points because

(A) The mobile electrons are tightly packed inside the metallic crystals.

(B) The mobile electrons move in one direction to produce electric current.

(C) It requires a considerable amount of energy to overcome the strong attractive force between the positive metal ions and the mobile electrons.

(D) When the metal ions are heated, the mobile electrons have greater kinetic energy and collide more often.

7. Which of the following options shows the correct meaning of the signs of enthalpy changes (ΔH) and entropy changes (ΔS) for any process?

	ΔH		**ΔS**	
	Sign	**Meaning**	**Sign**	**Meaning**
(A)	Positive	Exothermic	Positive	Products more ordered.
(B)	Positive	Endothermic	Negative	Products more random.
(C)	Negative	Endothermic	Positive	Products more random.
(D)	Negative	Exothermic	Negative	Products more ordered.

8. Which of the following correctly identifies the definition of an oxidant?

(A) loses electrons

(B) undergoes oxidation

(C) reduces the oxidising agent

(D) oxidises the reducing agent

9. Combustion reactions may be self-sustaining. This means that once started, they continue on their own, releasing heat energy to the environment. Why is this the case?

(A) $|\Delta H| > Ea$

(B) $|\Delta H| < Ea$

(C) $\Delta H = 0$

(D) $Ea = 0$

10. What volume of water needs to be added to 500 mL of 3.02 mol L^{-1} NaCl solution to make a 1 mol L^{-1} solution of NaCl?

(A) 165 mL

(B) 1010 mL

(C) 1510 mL

(D) 3020 mL

11. What is the number of molecules in 2.5 moles of water

(A) 1.5 molecules

(B) 1.5×10^{25} molecules

(C) 1.5×10^{24} molecules

(D) 1.5×10^{26} molecules

12. What is the enthalpy change for the reaction:

$$H_2O_{2(aq)} \rightarrow H_{2(g)} + O_{2(g)}$$

given the following reactions and their associated enthalpy changes?

$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$ $\Delta H = -200$ kJ/mol

$2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$ $\Delta H = +600$ kJ/mol

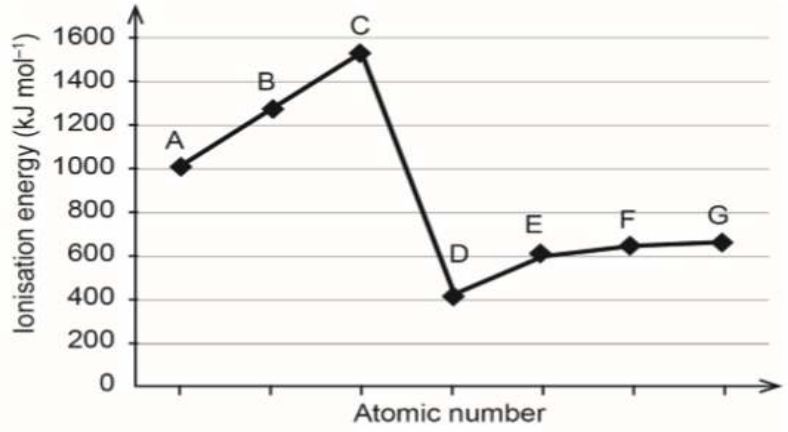
(A) -400 kJ/mol

(B) -200 kJ/mol

(C) +200 kJ/mol

(D) +400 kJ/mol

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



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

(A) BC

(B) A_2B

(C) EB_2

(D) A_2D

14. The ion $^{40}_{20}Ca^{2+}$ contains

(A) 20 protons, 20 neutrons and 20 electrons

(B) 18 protons, 20 neutrons and 20 electrons

(C) 20 protons, 18 neutrons and 22 electrons

(D) 20 protons, 20 neutrons and 18 electrons

15. Which of the following changes would have the greatest entropy increase?

(A) $O_{2(g)} + 2H_{2(g)} \rightarrow 2H_2O_{(l)}$

(B) $CuCO_{3(s)} \rightarrow CuO_{(s)} + CO_{2(g)}$

(C) $Cu(OH)_{2(s)} \rightarrow CuO_{(s)} + H_2O_{(l)}$

(D) $6CO_{2(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6(s)} + 6O_{2(g)}$

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

(A) +7

(B) +5

(C) +3

(D) –1

17. Which of the following is the most likely reason for differences between laboratory (experimental) and literature (theoretical) values of the enthalpy of combustion of a liquid fuel?

(A) The calorimeter used in a school laboratory is not well-insulated.

(B) The purity of the fuel investigated in not high enough in a school laboratory.

(C) The amount of fuel burned in a school laboratory is too small.

(D) The thermometers used in school laboratories are not very accurate.

18. Given that $\Delta G = \Delta H - T\Delta S$, identify the correct statement below.

(A) A reaction will always be spontaneous if ΔH is negative and ΔS is negative.

(B) A reaction will always be spontaneous if ΔH is negative and ΔS is positive.

(C) A reaction will always be spontaneous if ΔH is positive and ΔS is negative.

(D) A reaction will always be spontaneous if ΔH is positive and ΔS is positive.

19. Three metals, "X", "Y" and "Z" were tested to compare their reactivity. Samples of each metal were placed separately into test tubes, each containing a nitrate solution of the other metal ions. The results are shown below.

	X (s)	**Y (s)**	**Z (s)**
$\mathbf{X^{2+}}$		no reaction	no reaction
$\mathbf{Y^{2+}}$	Solid Y forms		Solid Y forms
$\mathbf{Z^{2+}}$	Solid Z forms	no reaction	

Based on these results, which of the following shows the metals in order of decreasing oxidant strength?

(A) $Y > X > Z$

(B) $X^{2+} > Z^{2+} > Y^{2+}$

(C) $Z > X > Y$

(D) $Y^{2+} > Z^{2+} > X^{2+}$

20. 15.46 g of powdered zinc reacts with an accurately measured mass of oxygen gas, producing 15.46 g of solid zinc oxide.

From these data, which of the conclusions below can be drawn?

(A) Zinc is the limiting reagent in this reaction.

(B) More oxygen added to the same mass of zinc will result in a higher yield of product.

(C) The mole ratio of zinc to oxygen gas used in the reaction was 4:3

(D) Equal moles of zinc and oxygen were used in the reaction.

Question 21 (2 marks) **Marks**

Use the data provided to find the enthalpy change for the following reaction, by applying Hess's Law.

$$\mathbf{CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)}$$

Reaction	**ΔH_f^o (kJ/mol)**
$C(s) + O_2(g) \rightarrow CO_2(g)$	- 394
$S(s) + O_2(g) \rightarrow SO_2(g)$	- 297
$C(s) + 2S(s) \rightarrow CS_2(l)$	+ 88

Show your working. **2**

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Question 22 (3 marks)

Calculate the concentration of sulfate ions present in a 500.0 mL aqueous solution containing 28.50 g of dissolved aluminium sulfate. **3**

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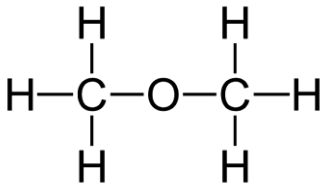
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Question 23 (8 marks)

Ethanol (C_2H_5OH) is a flammable chemical which boils at temperatures just above 78^oC and forms a miscible mixture with water. It can also be used as a sustainable replacement for fossil fuels

a) Draw an electron-dot diagram to represent this molecule. **2**

b) Dimethyl ether is a compound with the same molecular formula as ethanol yet has a drastically lower boiling point of -24^oC. The structure of dimethyl ether is shown to the right. **3**



With reference to the structure of each molecule, explain why dimethyl ether has a much lower boiling point than ethanol.

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c) A student filled a spirit burner with ethanol to heat 275 g of water in a copper can. He found that by burning 2.15 g of ethanol, the temperature of water rose by 28.5 K. All mass measurements were made on the same electronic balance (2 dp). **3**

Using this data calculate the heat released per mole of ethanol combusted.

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Question 24 (6 marks)

Students want to set up two half cells so that the resulting galvanic cell will generate an EMF. One half-cell was constructed using magnesium metal in a solution of magnesium nitrate, and the other half-cell was constructed using tin metal in tin(II) nitrate solution.

a) Draw a fully labelled diagram of the galvanic cell, including direction of electron flow. **3**

b) Write half equations for both half cells and using these construct a balanced overall equation to represent the reaction for the galvanic cell. **2**

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c) Calculate the overall cell potential generated by this galvanic cell. **1**

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Question 25 (5 marks) **Marks**

Sulfur dioxide gas can react with oxygen gas to form sulfur trioxide gas. The temperature of the reaction vessel becomes hot as the reaction proceeds.

a) Write a balanced chemical equation for this reaction. **1**

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b) Sketch a labelled energy profile diagram for this reaction. **2**

c) Vanadium pentoxide is a catalyst for this reaction. **2**

Explain the catalyst's role AND sketch and label the energy profile for the catalysed reaction on your energy profile diagram in part b).

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Question 26 (9 marks)

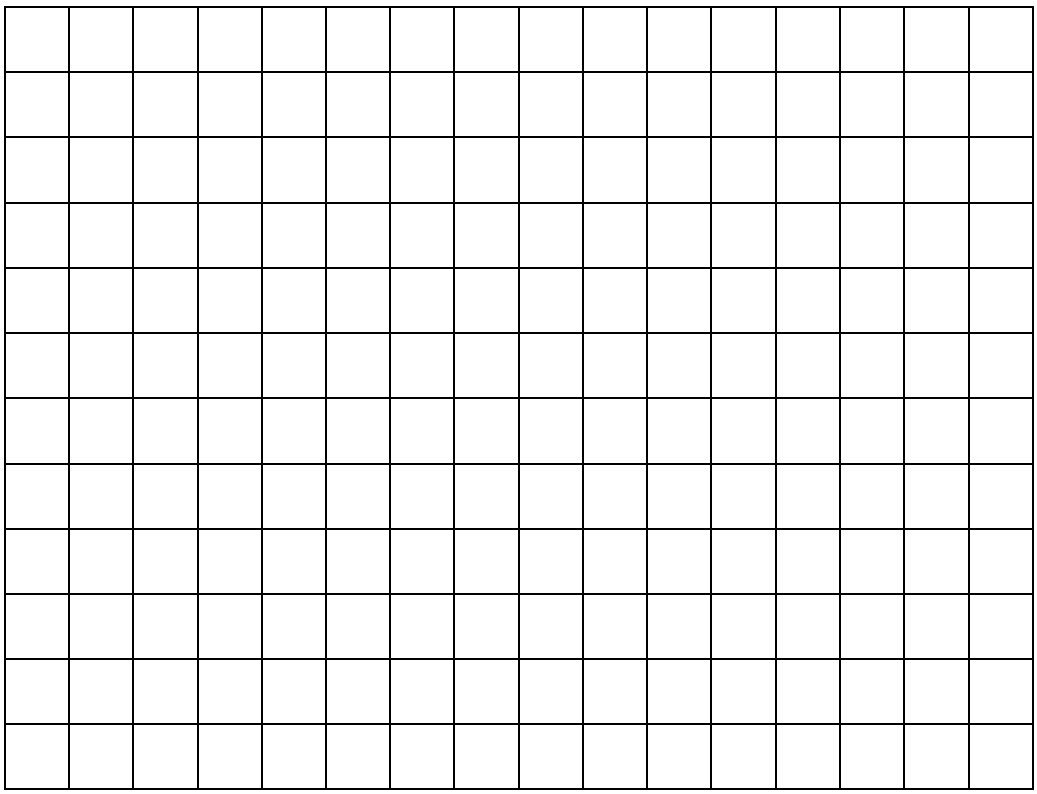
Magnesium reacts with hydrochloric acid according to the following equation.

$$Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_2 + H_{2(g)}$$

In an experiment the hydrogen gas was collected in a container and the volume of the gas produced over a period of time was recorded as shown below.

Time (s)	0	5	10	15	20	25	30	35	40	45
Volume of Hydrogen gas (mL)	0	12	22	30	36	41	45	48	50	50

a) Plot a graph showing volume of hydrogen gas produced versus time. Label this as curve 1. **4**



Question 26 continues on the next page.

b) Explain why the volume of hydrogen gas collected in each 5 second interval becomes smaller and smaller. **2**

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c) The reaction was carried out at 20^{o}C and 100kPa. Calculate the mass of hydrogen produced from this reaction. **2**

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d) The reaction apparatus was left set-up overnight, where the minimum temperature reached 7^{o}C. Assuming no gas was allowed to escape the apparatus, calculate the pressure the hydrogen gas exerted during the coldest part of the night. **1**

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Question 27 (7 marks)
The simplified solubility rules below may help you to answer this question.

General Rule	Exceptions
all Group I, nitrate and ammonium compounds are soluble	none
most chlorides are soluble	silver and lead (insoluble)
most sulfates are soluble	barium and lead (insoluble) calcium and silver (sparingly soluble)
most hydroxides are insoluble	group I, ammonium and barium compounds (soluble) calcium (slightly soluble)
most carbonates are insoluble	group I and ammonium compounds

A science teacher mixes solutions of barium nitrate and sodium carbonate.

a) Write a balanced chemical equation (including states) for the reaction. **1**

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b) Write the net ionic equation for the reaction. **1**

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c) Calculate the percentage mass of oxygen in the precipitate. **1**

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Question 27 continues on the next page.

d) Using the solubility rules above, suggest a method that could be followed to determine which of the compounds below is present in an unlabelled bottle known to contain **one** of these dissolved compounds. **4**

Explain how your observations would allow you to identify the unknown.

sodium nitrate, lithium sulfate, potassium hydroxide

(Assume you have access to typical laboratory equipment, as well as dropper bottles, each containing 0.1M solutions of any chemical you require in your procedure.)

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Question 28 (4 marks)

Dichloromethane and water are liquids that do not mix with each other. Some of their properties are shown in the table.

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

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

Assess the effectiveness of the two techniques when separating dichloromethane and water. **4**

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Question 29 (6 marks)

a) For reactions to be spontaneous, the entropy of the universe must increase. Scientists use a quantity called as Gibbs free energy to determine whether a process will be spontaneous. **2**

Explain how Gibb's free energy is used to determine if a chemical reaction is spontaneous.

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b) Methanol is used as a fuel for internal combustion engines. The following equation shows the reaction for combustion of methanol. **1**

$CH_3OH_{(l)} + \frac{3}{2} O_{2(g)} \rightarrow 2H_2O_{(l)} + CO_{2(g)}$ $\Delta H = -726$ kJ/mol

Explain what the sign of ΔH for the above equation indicates about the energy in the in the system before and after the reaction has occurred.

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c) The entropy change for the combustion is $\Delta S = 81.9$ J/mol/K. Explain why a positive entropy change is consistent with the equation for the combustion reaction. **1**

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d) Calculate whether the combustion of methanol will be spontaneous at 30°C. **2**

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Question 30 (5 marks)

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

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

If the molar mass of the compound is approximately 62 g mol-1, determine the molecular formula of antifreeze. **5**

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