Student Number _____

Caringbah High School
Year 11 Chemistry
Semester Exam 2022

Write all your answers in this answer booklet.

Use pen for written responses and pencil for diagrams and graphs.

Total Marks: 72

Task Length: 2 hour + 5 minutes reading time

PART A: Multiple Choice Questions (20 marks)

PART B: Longer Response Questions (52 marks)

Task Prepared by: S. Tudberry

OUTCOME	*MARK*
Knowledge and Understanding *Q*	*/54*
Working Scientifically *Q 30,31,32*	*/18*
Total *Q*	*/72*

PART A: Answer the multiple choice questions HERE. Circle the letter of the BEST answer.

Do NOT detach this page from the rest of the task.

1	**A B C D**	**11**	**A B C D**
2	**A B C D**	**12**	**A B C D**
3	**A B C D**	**13**	**A B C D**
4	**A B C D**	**14**	**A B C D**
5	**A B C D**	**15**	**A B C D**
6	**A B C D**	**16**	**A B C D**
7	**A B C D**	**17**	**A B C D**
8	**A B C D**	**18**	**A B C D**
9	**A B C D**	**19**	**A B C D**
10	**A B C D**	**20**	**A B C D**

PART A: Circle the letter of the BEST answer on the grid (20 marks)

1. *Which of the following ions has an electron arrangement which is the same as an inert gas?*

A. O^{2-}
B. Li^{2+}
C. Be^{+}
D. Al^{2+}

2. *Which statement below **best explains** why ethanol is difficult to separate from water using the process of distillation?*

A. Ethanol is soluble in water in any proportion.
B. The boiling points of the two liquids are very similar.
C. Ethanol and water form extensive hydrogen bonding to each other.
D. The dispersion forces between ethanol and water are similar in strength.

3. *A sample of iron is found to contains three isotopes and has a relative atomic mass of 55.9 amu. The table below shows data on two of the isotopes.*

Mass number of isotope	***56***	***57***
Abundance in sample (%)	*91.85*	*2.30*

What is the best estimate for the mass number of the third isotope of iron present in the sample?

A. 52
B. 53
C. 54
D. 55

4. *Which of the following gives the correct electron configuration for the ions in calcium chloride?*

	Calcium	*Chloride*
A.	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$	$1s^2 2s^2 2p^6 3s^2 3p^5$
B.	$1s^2 2s^2 2p^6 3s^2 3p^6$	$1s^2 2s^2 2p^6 3s^2 3p^6$
C.	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^4$	$1s^2 2s^2 2p^6 3s^2 3p^4$
D.	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	$1s^2 2s^2 2p^6 3s^2 3p^7$

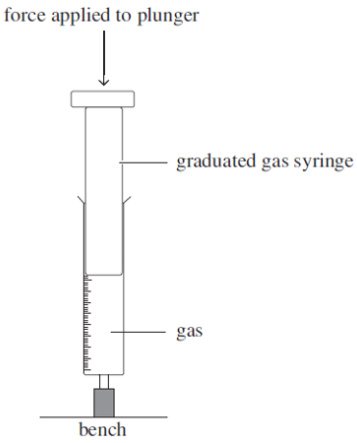
5. *The table shows the properties of K, L, M and N*

	Boiling point (°C)	*Electrical conductivity in solid state*	*Electrical conductivity in molten state*
K	750	no	yes
L	–31	no	no
M	3985	no	no
N	2862	yes	yes

Which of the following best classifies these substances?

	K	*L*	*M*	*N*
A.	ionic	covalent molecular	covalent network	metallic
B.	metallic	covalent molecular	covalent network	ionic
C.	covalent molecular	covalent network	ionic	metallic
D.	ionic	covalent network	ionic	covalent molecular

6. *A student pushed down as hard as they could onto a plunger of a sealed plastic syringe.*



The student compressed the air inside the syringe to a volume of 11.00 mL. When they released their hand, the air inside the syringe equalised with the pressure outside, which was 1.00 atm. The final volume of air inside the syringe was 42.00 mL. The air temperature of the syringe did not change.

Which of the following options correctly calculates the pressure inside the syringe just before it was released by the student's hand AND identifies the law used to perform this calculation?

A. 3.82×10^{-3} atm by Boyle's Law
B. 3.82×10^{-3} atm by Charles' Law
C. 3.82 atm by Boyle's Law
D. 3.82 atm by Charles's Law

7.	*Copper(II) sulfide can be converted to copper(II) oxide according to the **unbalanced equation** below.* $CuS(s) + O_2(g) \rightarrow CuO(s) + SO_2(g)$ *What volume of $SO_2(g)$ would be produced from a reaction requiring 270 L of oxygen to completely consume the CuS initially present?* *(all gas volumes measured at the same temperature and pressure)* *A. 135 L* *B. 180 L* *C. 270 L* *D. 405 L*	
8.	*A student followed the steps below to produce two solutions of barium hydroxide of different concentrations.* *STEP 1:* *17.10 g of barium hydroxide powder was weighed and added to a 100.0mL volumetric flask.* *Distilled water was added to the calibration line on the flask.* *This solution was labelled as 'Solution A'.* *STEP 2:* *5.00mL of this solution was withdrawn by volumetric pipette and added to a second volumetric flask. Distilled water was added to the calibration line on the flask. This solution was labelled as 'Solution B'.* *The hydroxide concentration of 'Solution B' was measured at $0.04 mol L^{-1}$.* *Given this value, what was the volume of the volumetric flask used in STEP 2?* *A. 120 mL* *B. 125 mL* *C. 245 mL* *D. 250 mL*	
9.	*When black manganese dioxide powder is added to hydrogen peroxide (H_2O_2), it catalyses the decomposition reaction of hydrogen peroxide to produce water, some of which vaporises due to the heat produced, and oxygen gas. Without the addition of the catalyst, hydrogen peroxide can be stores for several weeks without decomposing.* *Which of the following is the best explanation for this?* *A. The change in enthalpy is positive* *B. The change in entropy is negative.* *C. The activation energy at room temperature is high.* *D. The Gibbs free energy is positive.*	

10. *The solubility rules, such as those shown below provide general qualitative data about the solubility of a range of ionic compounds, which can be useful when identifying ions in an unknown compound.*

Anion or cation present in salt	*General Solubility Rule*	*Main exceptions*
Group I metal	*All salts soluble*	*No exceptions*
Ammonium	*All salts soluble*	*No exceptions*
Nitrate	*All salts soluble*	*No exceptions*
Chloride	*Most salts soluble*	*Lead(II); mercury(II), silver*
Sulfate	*Most salts soluble*	*Lead(II); mercury(II), silver, barium*
Carbonate	*Most salts insoluble*	*Group I and ammonium cations*
Hydroxide	*Most salts insoluble*	*Group I and ammonium cations, barium*

*In an experiment, a student added lead (II) nitrate solution to an aqueous solution of colourless solution of an ionic compound labelled **X**. A white, opaque mixture was produced.*

*After filtration of the mixture, a small sample of the white solid residue, **Y**, was added to sulfuric acid, and fizzing occurred to produce a colourless gas, **Z**.*

*Which alternative below identifies possible compounds **X**, **Y** and **Z**, given the observations provided above?*

	X	***Y***	***Z***
A.	$BaCO_3$	$PbCO_3$	CO_2
B.	K_2CO_3	$PbCO_3$	CO_2
C.	Na_2SO_4	$NaNO_3$	SO_2
D.	$CuSO_4$	$Cu(NO_3)_2$	SO_2

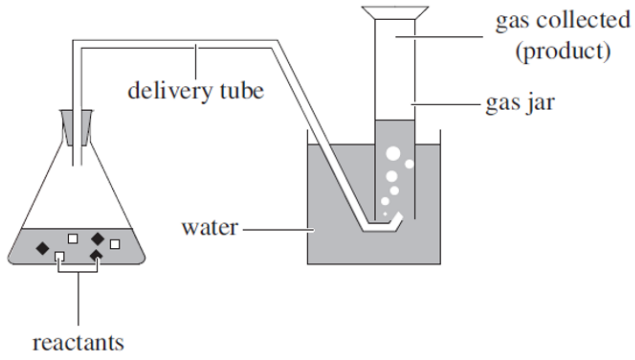
11. *The table shows the results obtained by the students investigating the relative activity of metals X, Y and Z using displacement reactions. The metals were placed into solutions containing metal ions X^{2+}, Y^{2+} and Z^{2+}.*

Metal	*Solution of X^{2+}*	*Solution of Y^{2+}*	*Solution of Z^{2+}*
X	no reaction	displacement	displacement
Y	no reaction	no reaction	no reaction
Z	no reaction	displacement	no reaction

Using the information in the table, which of the following gives the correct order of activity of these metals?

A. $Z < X < Y$
B. $X < Y < Z$
C. $Y < Z < X$
D. $Y < X < Z$

12. *Students conducted an experiment to measure the amount of gas generated when different masses of reactants were mixed in 100.00 mL of water. The experiment is shown in the diagram.*



Which of the following correctly identifies the variables of this experiment?

	Independent Variable	*Dependant Variable*	*Controlled Variable*
A.	*Mass of reactants*	*Temperature*	*Gas collected*
B.	*Volume of water*	*Volume of gas collected*	*Mass of reactants*
C.	*Mass of reactants*	*Volume of gas collected*	*Temperature*
D.	*Volume of gas collected*	*Temperature*	*Mas of reactants*

13. *Which of the following is always true for a reaction with a negative value of Gibbs free energy?*

A. The entropy will also be negative
B. The enthalpy will also be negative.
C. The reaction will be spontaneous.
D. The randomness/disorder will increase

14. *Several chemical equations are shown below.*

I $\mathrm{CO(NH_2)_2}(s) + \mathrm{H_2O}(l) \rightarrow \mathrm{CO_2}(g) + 2\mathrm{NH_3}(g)$

II $2\mathrm{NO_2}(g) \rightarrow \mathrm{N_2O_4}(g)$

III $\mathrm{C_3H_8}(g) + 5\mathrm{O_2}(g) \rightarrow 3\mathrm{CO_2}(g) + 4\mathrm{H_2O}(g)$

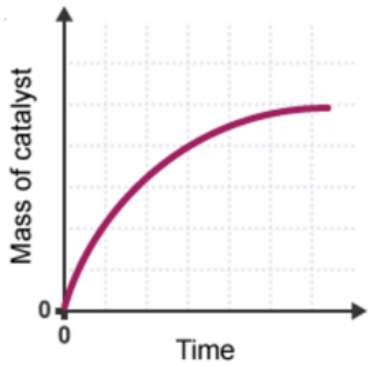
Which of the following correctly identifies the equations(s) that have increasing entropy?

A. I and III only
B. III only
C. I, II and III
D. I and II only

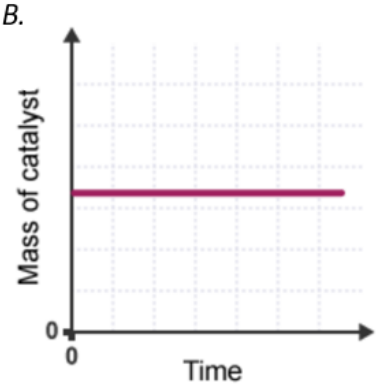
15. *The decomposition of hydrogen peroxide is catalysed by adding a small amount of manganese (IV) oxide.*

Which of these graphs shows the mass of the catalyst as the reaction takes place?

A.



B.



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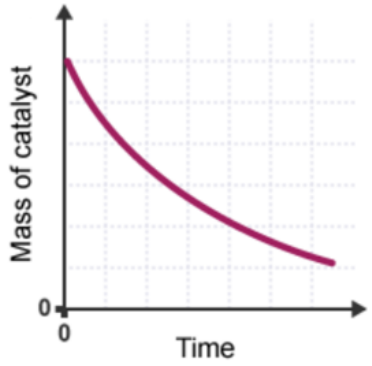
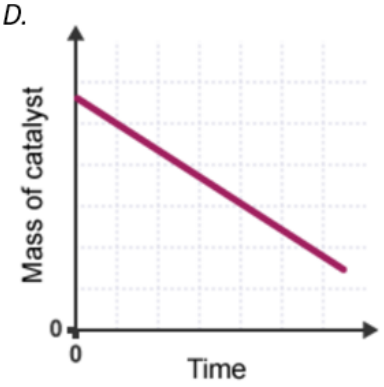


D.



16. *A particular reaction is spontaneous at very low temperatures, but as the temperature increases, it eventually becomes non-spontaneous.*

Based on these data, which alternative below shows the correct sign of ΔH^o and ΔS^o for this reaction?

	ΔH^o $(kJmol^{-1})$	ΔS^o $(JK^{-1}mol^{-1})$
A.	$+ve$	$+ve$
B.	$-ve$	$-ve$
C.	$+ve$	$-ve$
D.	$-ve$	$+ve$

17.

In the upper atmosphere, the following two reactions involving the allotropic forms of oxygen (O_2 and O_3) can take place.

$\mathbf{O_2(g) \rightarrow 2O\ (g)}$ $\quad \Delta H = 498\ kJmol^{-1}$

$\mathbf{3O_2(g) \rightarrow 2O_3\ (g)}$ $\quad \Delta H = 284\ kJmol^{-1}$

What energy change would occur if 1.807 x 10^{24} oxygen atoms combined to form diatomic oxygen molecules?

A. 747 kJ would be released.
B. 747 kJ would be absorbed.
C. 1494 kJ would be released.
D. 1494 kJ would be absorbed

18.

An ore of copper, malachite, is composed primarily of copper (II) carbonate. When it is heated, it produces copper (II) oxide and carbon dioxide gas.

If a 12.95 g sample is 95% copper carbonate, how much mass of copper oxide would be produced from its decomposition by heat?

A. 0.83 g
B. 7.92 g
C. 8.33 g
D. 9.51 g

19.

2.0 g of calcium carbonate reacted with 200 mL of 0.1 molL^{-1} of nitric acid.

Which of the following is a correct statement about this reaction?

A. 1.64 g of dry calcium nitrate salt is produced by the reaction.
B. 9.9 L of carbon dioxide gas would be produced in the reaction.
C. Approximately 0.5 g of calcium carbonate will remain after the reaction.
D. An excess of 0.01 mol of nitric acid remains at the end of the reaction.

20. *Baking soda ($NaHCO_3$) is often used to extinguish fires involving fats and oils. As it decomposes it produces CO_2 gas, which further extinguishes the flame, as well as sodium carbonate and water, as shown in the equation.*

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

Standard enthalpies of formation at 25°C

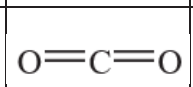
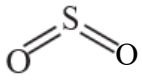
Substance	$\Delta H^\circ_f (kJ\ mol^{-1})$
$NaHCO_3(s)$	–947.7
$Na_2CO_3(s)$	–1131
H_2O (l)	–285.9
H_2O (g)	–241.8
CO (g)	–110.5
CO_2 (g)	–393.5

Which of the following gives the correct calculation of $H°_f$ for the decomposition reaction at 25°C?

A. -818 kJ mol^{-1}
B. -129.1 kJ mol^{-1}
C. +129.1 kJ mol^{-1}
D. +129.1 kJ mol^{-1}

PART B: Longer Answers

21. *a. The table below contains some information about sulfur dioxide and carbon dioxide.* **3**

	Shape of molecule	Electronegativity difference between elements	Solubility in water at 25 °C (gL^{-1})
carbon dioxide		1·0	1·45
sulfur dioxide		1·0	94

Explain fully why carbon dioxide is much less soluble in water than sulfur dioxide is in water.

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22. *Paracetamol is a medication used to treat fever and mild pain. Its molecular formula is $C_8H_9O_2N$.* **2**

A sample of pure paracetamol is analysed and found to contain 1.27 g of carbon.

Calculate the mass of oxygen in the same sample.

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23. *The electron configuration of two elements, identified as "D" and "E", are shown in the following table.*

Element	*Electron configuration*
D	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$
E	$1s^2 2s^2 2p^6 3s^2 3p^5$

a. Give a possible formula of a compound formed between these elements, using the letters D and E to represent the elements. **1**

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b. A compound formed from these two elements has a melting point of -8.5°C and a boiling point of 60.4°C. What is the physical state of this compound at standard room temperature? **1**

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*c. Predict **ONE** physical properties of this compound in the solid state, apart from its melting and boiling point. Fully justify your predictions based on the information provided.* **2**

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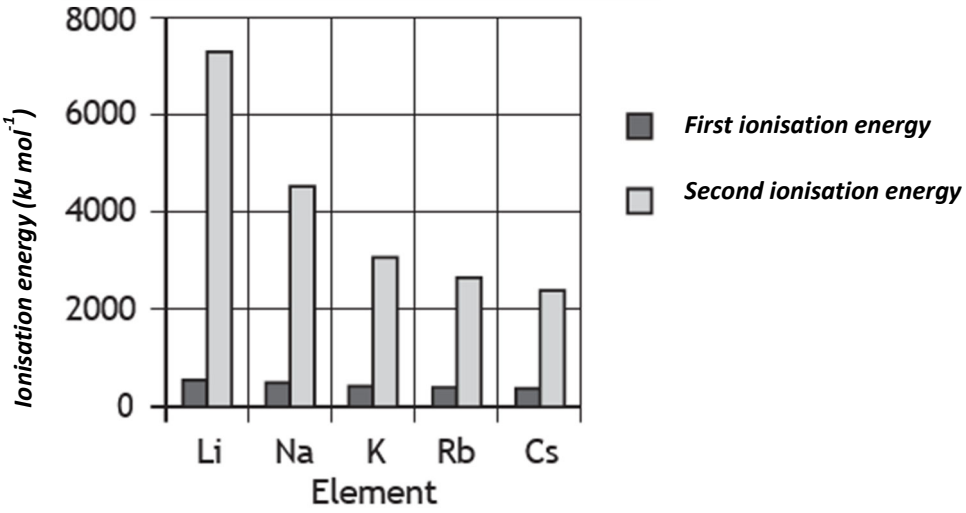
24.	*The graph below shows data on the first and second ionisation energies of the Group 1 Metals.*  *Explain, using specific examples from the graph, how details of the atomic structure of these elements can be used to account for the trends shown.* …… …… …… …… …… …… …… ……	**4**

25.

*Triacetone triperoxide, commonly referred to as **TATP**, is a crystalline solid at room temperature which can be used as a powerful explosive.*

The compound is highly unstable, with weak oxygen-oxygen single bonds.

Approximately <u>80% as powerful as TNT</u>, its decomposition in air releases significant amounts of energy.

The compound is more dangerous to handle than many other explosives, as a firm shock or knock is enough to trigger an explosion.

*a. A chemist analysed a sample of white solid suspected to be **TATP,** and found that the sample contained 48.7% C, 43.2 % O, 8.1% H by mass.* **2**

Calculate the empirical formula of the solid, assuming it is pure.

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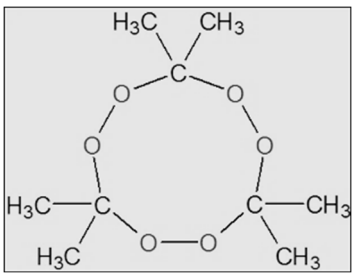
*b. The molecular structure of **TATP** is shown below.*



Demonstrate that the empirical formula determined in part (a) is consistent with the structure shown above. **2**

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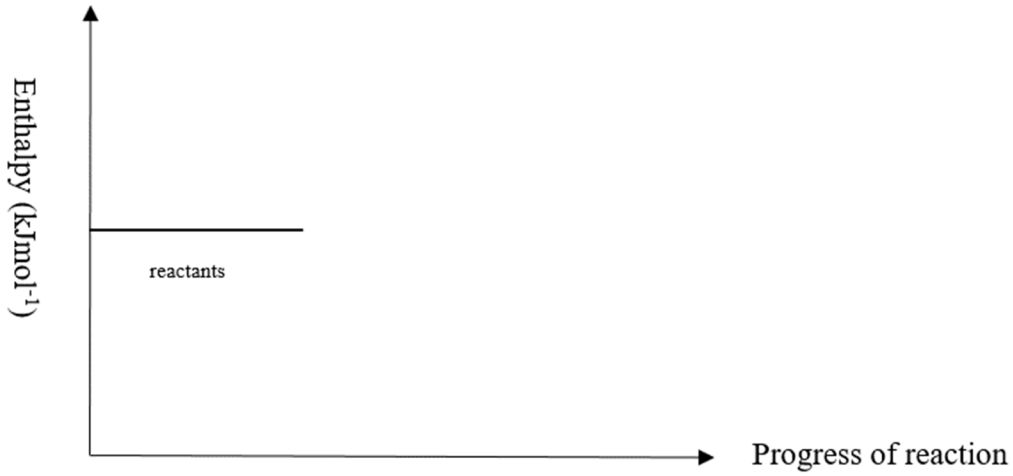
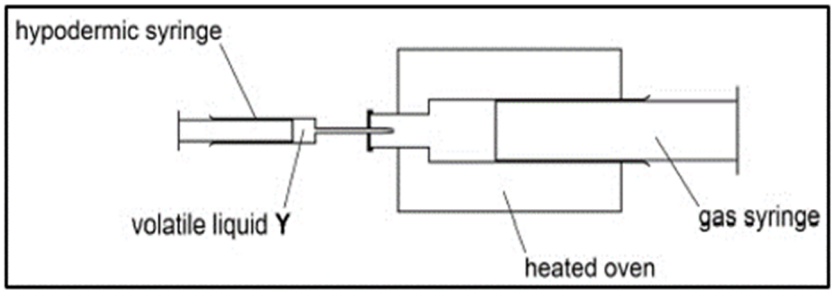
	c. Complete a labelled sketch of the energy profile expected for the decomposition of a mole of TATP, given the description of the compound provided.  	**2**
26.	*Using collision theory, explain the effect of increasing temperature on reaction rates.* …… …… …… …… …… …… …… ……	**3**
27.	*The first step of Uranium-235 decay is an alpha decay. Write the nuclear equation for this process.* …… …… …… …… ……	**2**

28. *To estimate the molar mass of an unknown volatile liquid Y, a student carried out an experiment as described below.*

The student used a hypodermic syringe to inject a sample of liquid Y into a gas syringe in an oven set to a specific temperature.



At the oven temperature, liquid Y vaporised, and the vapour entered the syringe.

The gas volume after complete vaporisation was carefully measured from a scale on the syringe.

The student's results are shown in the table.

Mass of hypodermic syringe and liquid Y before injection	*10.91 g*
Mass of hypodermic syringe and liquid Y after injection	*10.70 g*
Oven temperature	*98.1 °C*
Atmospheric pressure	*102 kPa*
Increase in volume in gas syringe after injection of Y	*85.0 mL*

a. Use the results to determine the molar mass of liquid Y. Show all working. **3**

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b. Some of the liquid injected did not evaporate because it dripped from the hypodermic syringe before it was placed into the oven.
Identify the effect of this error on the value of the molar mass of Y calculated from the experimental results. **1**

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29. *Students set up an experiment where copper wire was wound into a coil and placed in a beaker containing 100.00 mL of silver acetate ($AgCH_3COO$), as shown in diagram A. The solution did not have a concentration displayed on its label. Diagram B shows the beaker after it had been left in a cupboard overnight.*

diagram *A*

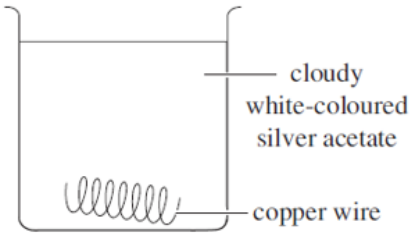
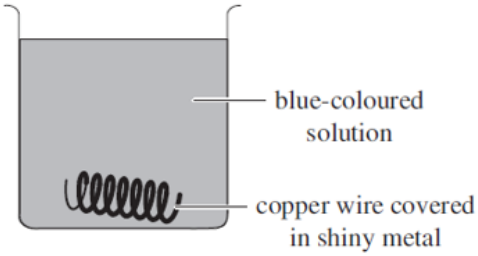


diagram *B*



a. Write a balanced net ionic equation for this reaction. **1**

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b. Explain why the solution changed from a cloudy white colour in diagram A to a blue solution with the copper wire covered in shiny metal in Diagram B. **2**

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c. The original mass of the copper wire was 5.15 g. After the solution had been left in the cupboard overnight, the shiny silver deposit was cleaned off the wire and it was rinsed, dried and reweighed, with the final mass of the wire being 4.50g.

Calculate the concentration of the silver acetate solution in moles per litre. **3**

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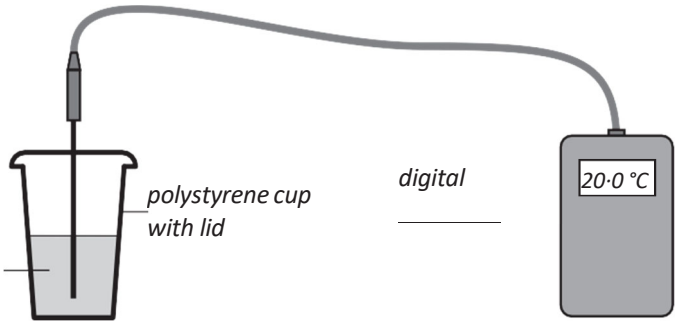
30. *A group of students carried out an investigation into the energy changes that take place when sodium hydroxide solid dissolves in water.*

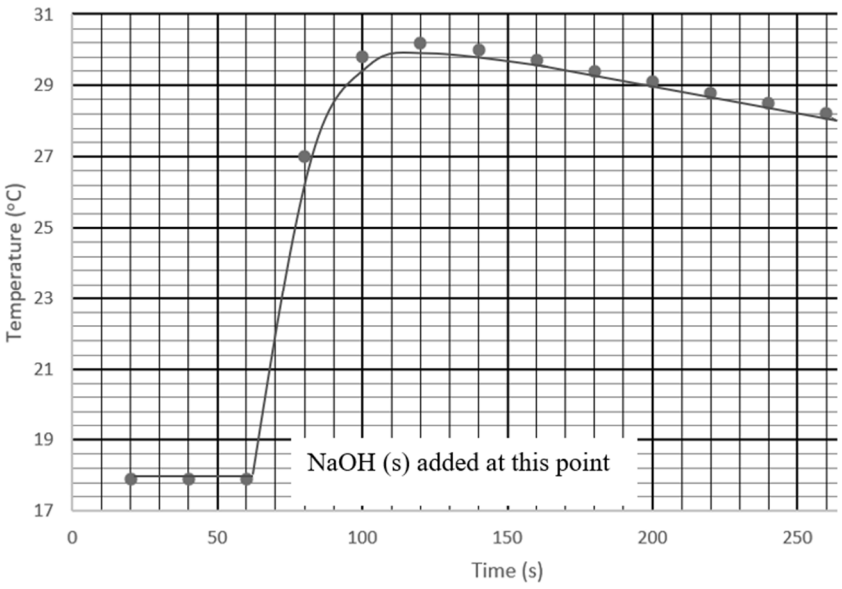
The following apparatus was used as a simple calorimeter to determine the change in temperature.



The experiment was carried out as follows.

1. *100.0 g of deionised water was added to the cup.*
2. *The stopwatch was started, the water stirred continuously, and the temperature recorded every 20 seconds.*
3. *After 60 seconds, an accurately weighed mass 5.00 g sample of the sodium hydroxide was added to the water and the temperature recorded every 20 seconds.*

The results of the experiment are graphed below.



a. Use the data in the graph shown to calculate the molar heat of solution for NaOH (s). **3**

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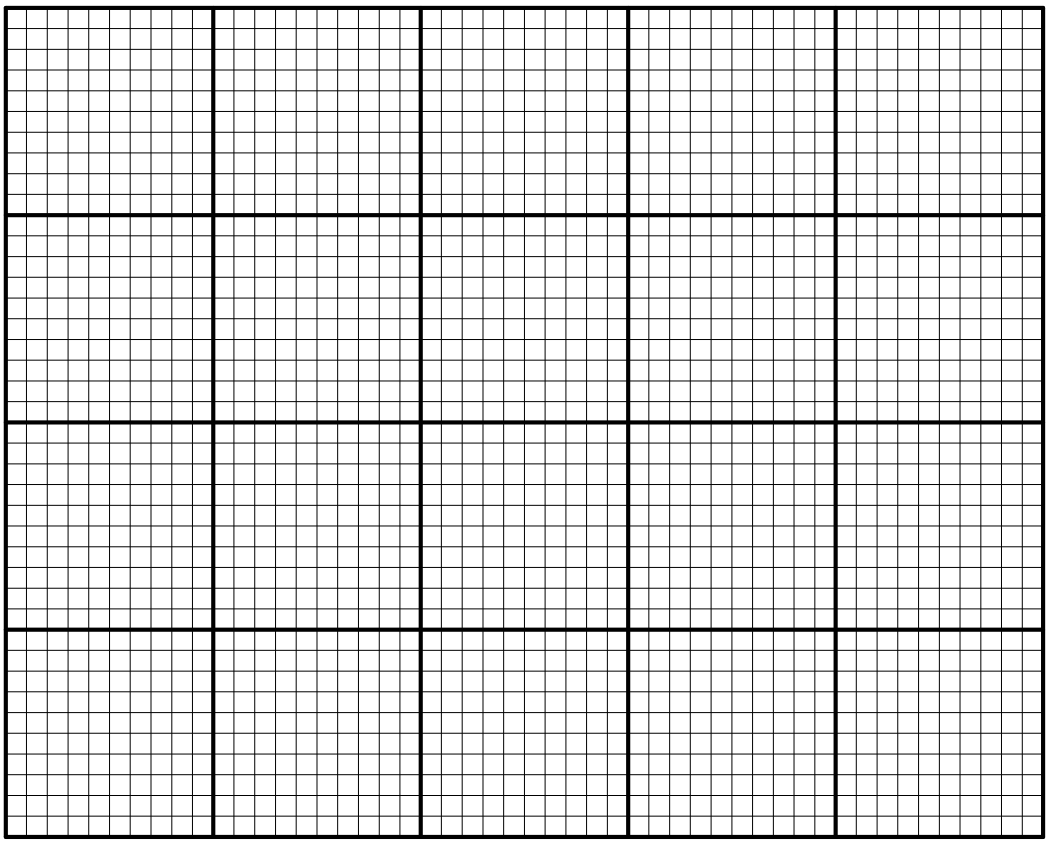
	b. Justify the features of the calorimeter used in the investigation. …… …… …… …… ……	**2**
31.	*Given the following data:* $C\ (s) + O_2\ (g) \rightarrow CO_2(g)$ $\quad \Delta H = -393\ kJ/mol$ $2H_2\ (g) + O_2\ (g) \rightarrow 2H_2O\ (g)$ $\quad \Delta H = -484\ kJ/mol$ $6C\ (s) + 6H_2\ (g) + 3O_2\ (g) \rightarrow C_6H_{12}O_6\ (s)$ $\quad \Delta H = -984\ kJ/mol$ *Calculate the enthalpy change for the combustion of 90.0g of glucose ($C_6H_{12}O_6$). Show all working.* …… …… …… …… …… …… …… …… ……	**3**

32. *The results of an investigation in which different volumes of a 0.10 molL^{-1} sodium chloride solution are added to separate 50.0 mL samples of silver nitrate solution are shown in the table below.*

After each reaction, the silver chloride solid was separated via filtration, dried and weighed.

Volume sodium chloride (aq) added (mL)	*Volume silver nitrate (aq) added (mL)*	*Mass of silver chloride produced (g)*
20.0	*50.0*	*0.29*
40.0	*50.0*	*0.58*
60.0	*50.0*	*0.87*
80.0	*50.0*	*1.16*
100.0	*50.0*	*1.44*
120.0	*50.0*	*1.44*
140.0	*50.0*	*1.43*
150.0	*50.0*	*1.45*

a. Construct a correctly formatted graph to show the relationship between the volume of sodium chloride solution added and the mass of silver chloride produced. **4**



	b. Write a balanced chemical equation for the reaction that occurred in this investigation. …… *c. Account for the shape of the graph.* …… …… …… …… *d. Use the graph and any other information provided to calculate the molarity of the silver nitrate solution used in this experiment.* …… …… …… …… …… …… …… ……	**1** **2** **3**