TANJONG KATONG GIRLS' SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR EXPRESS
CHEMISTRY

CANDIDATE NAME						
CLASS	**4**			INDEX NUMBER		

CHEMISTRY

6092/02

Paper 2

15 August 2025
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	
Section B	
Total	**/ 80**

Section A

Answer **all** questions.

1 The electron arrangement in the outer shells of five elements, **A**, **B**, **C**, **D** and **E** are shown in Fig.1.1. All elements are from Period 3 of the Periodic Table.

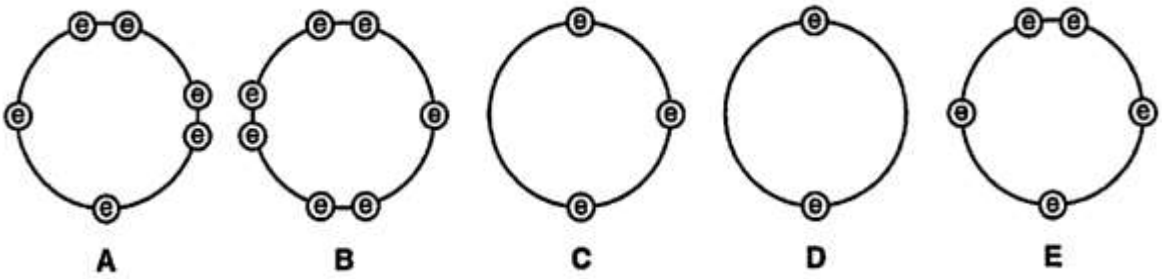


Fig. 1.1

Use the letters **A**, **B**, **C**, **D** and **E** to answer the following questions.

Each letter may be used once, more than once or not at all.

(a) Which **two** elements are most likely to be metals?

…….. and ……..... [1]

(b) Which element has an atomic number of 16?

…….[1]

(c) Which element will form double covalent bonds with an oxygen atom?

…….[1]

(d) Which **two** elements will form an ionic compound with the formula type XY?

……. and ……..[1]

(e) Which element will form an oxide that reacts with both acids and bases?

…….[1]

[Total: 5]

2 **(a)** Table 2.1 shows information of atoms.

Complete Table 2.1.

Table 2.1

atoms	number of protons	number of neutrons	number of electrons
$^{39}_{19}K$			
		28	24

[2]

(b) The strength of interactions between particles determines whether the substance is a solid, liquid or gas at room temperature.

Potassium oxide, K_2O, is a solid while sulfur trioxide, SO_3, is a liquid at room temperature.

(i) Explain in terms of structure and bonding, why potassium oxide is a solid while sulfur trioxide is a liquid at room temperature.

……

……

……

……

……[3]

(ii) State one other difference in the physical properties of potassium oxide and sulfur trioxide.

……

……[1]

(iii) Draw a 'dot-and-cross' diagram to show the bonding in K_2O.

Show all outer shell electrons.

[2]

(c) Potassium oxide, aluminium oxide and sulfur trioxide are each added to separate samples of dilute sulfuric acid and aqueous sodium hydroxide.

Complete Table 2.2 to show whether a reaction occurs in each case.

Put a tick (✓) in the box if a reaction occurs.

Table 2.2

	dilute sulfuric acid	dilute sodium hydroxide
potassium oxide		
aluminium oxide		
sulfur trioxide		

[2]

[Total: 10]

3 A student performs three experiments. In the first experiment, she adds large pieces of copper(II) carbonate to dilute hydrochloric acid. Copper(II) carbonate added is in excess.

(a) Fig. 3.1 shows how the mass of the reaction mixture changes with time as the reaction proceeds.

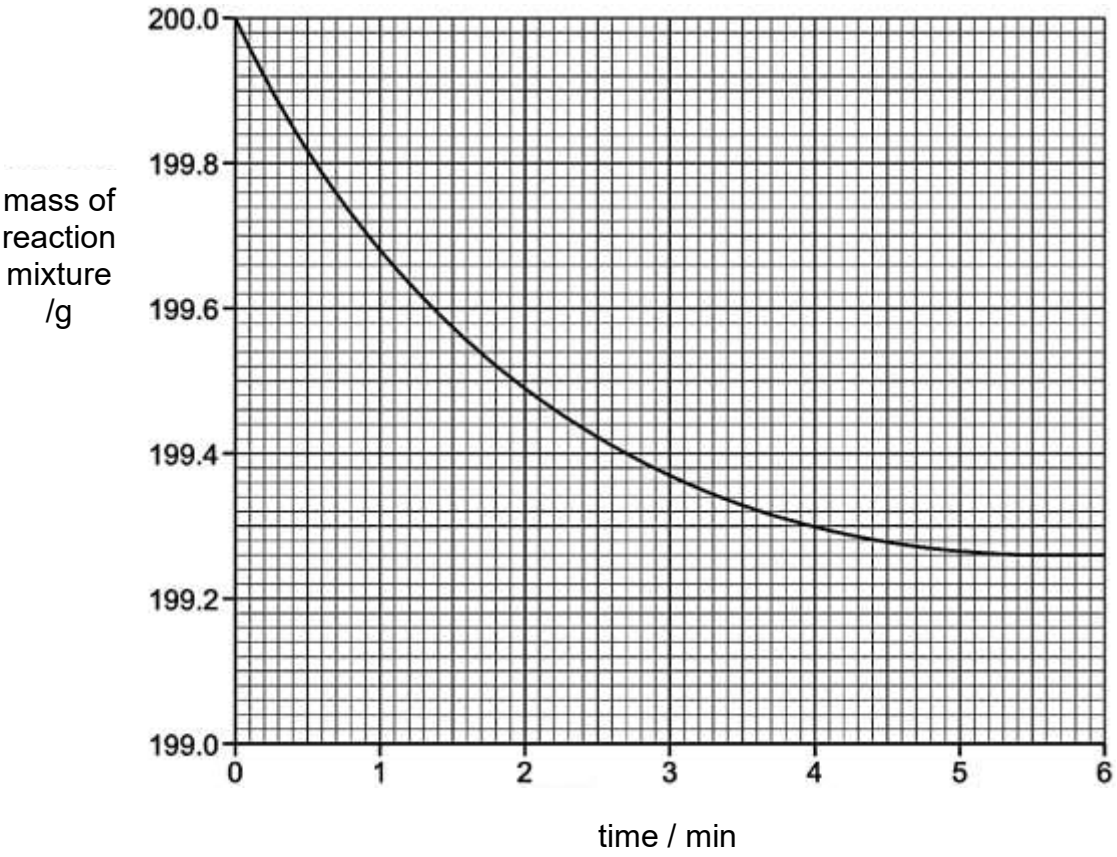


Fig. 3.1

(i) In the second experiment, powdered copper(II) carbonate is used instead of large pieces of copper(II) carbonate. All other conditions and the mass of copper(II) carbonate stay the same.

Draw a line on the grid in Fig. 3.1 to show how the mass of the reaction mixture changes with time when powdered copper(II) carbonate is used.

[1]

(ii) In the third experiment, the student uses large pieces of copper(II) carbonate and hydrochloric acid of a higher concentration.

All other conditions stay the same.

Describe and explain the difference in the rate of reaction when hydrochloric acid of a higher concentration is used.

……

……

……[2]

(b) After the copper(II) carbonate has reacted completely with hydrochloric acid, the student places a clean strip of zinc metal into the resulting solution.

Suggest and explain the observations.

……

……

……[2]

(c) Describe what you see when:

(i) a few drops of aqueous ammonia are added to an aqueous solution containing copper(II) ions.

……[1]

(ii) excess aqueous ammonia is added to an aqueous solution containing copper(II) ions.

……[1]

(d) Describe how to prepare crystals of ammonium chloride by reacting aqueous ammonia with dilute hydrochloric acid.

……

……

……

……

……[3]

[Total: 10]

4 **(a)** Petrol is a mixture of hydrocarbons that includes octane, C_8H_{18}.

(i) Write an equation for the complete combustion of octane.

……..[1]

(ii) Suggest a reason why the fuel in an internal combustion engine is unlikely to undergo complete combustion.

……..[1]

(b) Exhaust gases from petrol engines contain compounds which are harmful to the environment. These includes oxides of carbon and nitrogen.

(i) Write an equation to show the removal of carbon monoxide **and** nitrogen monoxide from the exhaust gases.

……..[1]

(ii) Thiophene, C_4H_4S, is present in crude oil fractions. During combustion, it produces sulfur dioxide. Combustion of fuels also produces nitrogen dioxide.

Explain the effects of sulfur dioxide and nitrogen dioxide being released into the atmosphere.

……..

……..

……..

……..

……..[2]

(c) Explain, in terms of specific processes, how the carbon cycle regulates the amount of carbon dioxide in the atmosphere.

……

……..[1]

[Total: 6]

5 **(a)** Fig. 5.1 show some organic compound reactions.

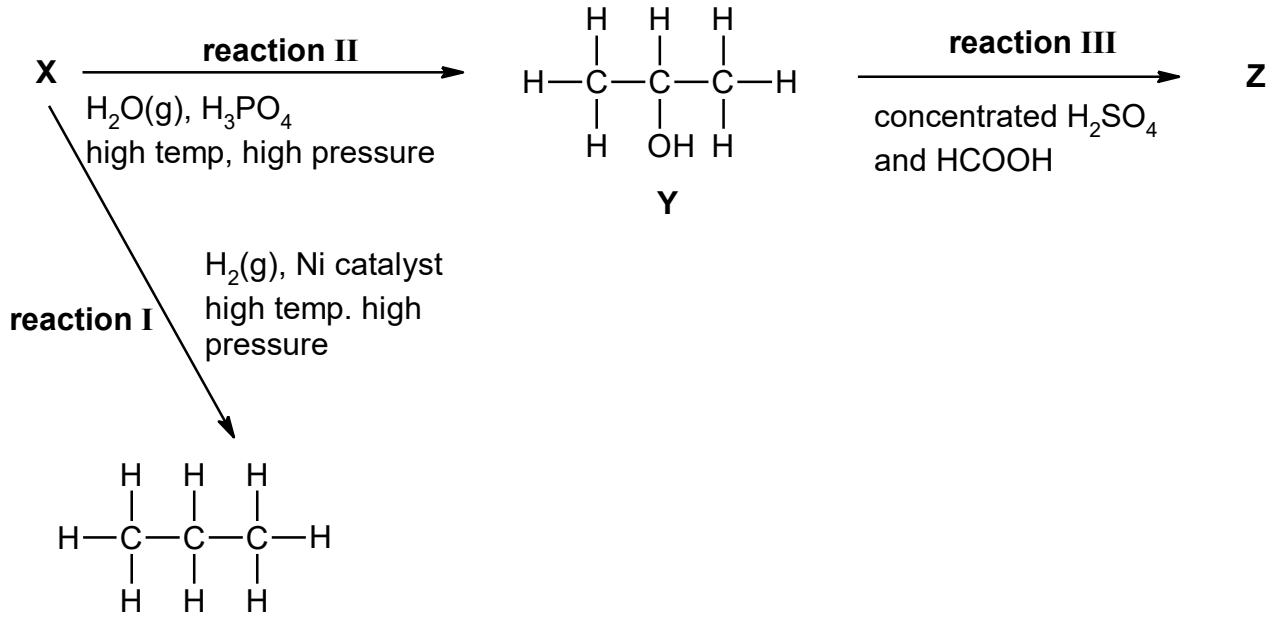


Fig. 5.1

(i) Draw the organic compounds, **X** and **Z** in the spaces provided. [2]

X:

Z:

(ii) Reaction II produces compound **Y** and one other isomer. Draw the full structural formula of the isomer.

[1]

(b) After the fermentation of sugar from sugarcane to produce ethanol, some ethyl ethanoate is found to be present in the mixture.

Suggest how this ethyl ethanoate may be formed.

……

……

……..[2]

(c) A student is given three unlabelled bottles containing colourless liquids.

One of the liquids is ethanol, one is ethanoic acid, and the other is ethyl ethanoate.

Describe the reagents and conditions for a chemical test that gives positive result **only** with ethanol. Describe what would be observed.

reagents and conditions ……....

……..[1]

observations ……

……..[1]

(d) 1.00 g of a powder contains

0.30 g of glucose, $C_6H_{12}O_6$

0.45 g of citric acid, $C_6H_8O_7$

0.25 g of sodium hydrogencarbonate, $NaHCO_3$

In the presence of water, the powder effervescences as citric acid reacts with the sodium hydrogencarbonate to form sodium citrate, $Na_3(C_6H_5O_7)$.

$$3NaHCO_3(s) + C_6H_8O_7(aq) \rightarrow Na_3(C_6H_5O_7)(aq) + 3CO_2(g) + 3H_2O(l)$$

(i) Determine the limiting reactant when 1.00 g of this powder reacts.

[2]

(ii) In an experiment, 0.043 dm^3 of CO_2 is produced in the above reaction from using 1.00 g of the powder.

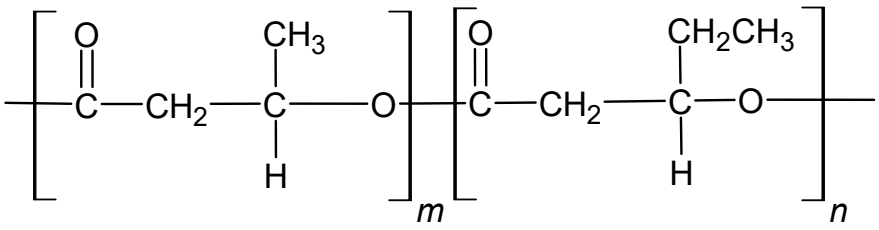
Calculate the percentage yield obtained in this experiment.

[2]

[Total: 11]

6 **(a)** Synthetic polymers are macromolecules which have many uses. They are made from monomers which combine in polymerisation reactions.

The synthetic polymer, PHBV, is a polymer which is often used in packaging material.



PHBV

(i) Draw the structural formulae of the two monomers used to make PHBV.

[2]

(ii) State the type of reaction used to make PHBV.

……..[1]

(b) **(i)** Poly(ethene) is an example of a poly(alkene) and can be used in food plastic wrapping.

This polymer macromolecule has a relative molecular mass of between 15 000 and 20 000.

Calculate the minimum number of repeating units needed to be present in one macromolecule of poly(ethene).

[2]

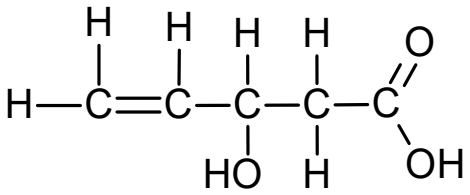
(ii) Suggest why people are encouraged to recycle poly(alkenes).

……..

……..

……..[1]

(c) Compound **X** can be polymerised to form two different polymers.



X

Draw a repeat unit for each of the polymer.

repeat unit for polymer 1

[1]

repeat unit for polymer 2

[1]

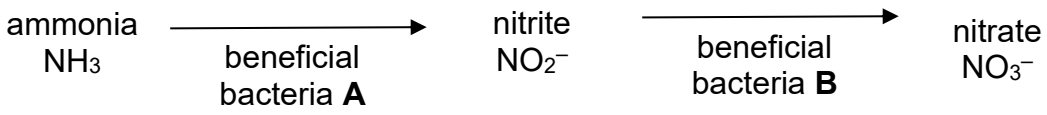
[Total: 8]

7 Role of water chemistry in aquarium health

Water chemistry plays a critical role in the well-being of fishes in an aquarium. Fish waste releases ammonia, NH_3, and ammonium ions, NH_4^+, into water, both of which are toxic to fish. NH_3 is highly toxic to fish, whereas NH_4^+ is significantly less harmful.

Nitrification process

During nitrification, NH_3 and NH_4^+ are broken down by beneficial bacteria into less toxic nitrate ions, NO_3^-, as shown in Fig. 7.1.



$$NH_4^+ + 2O_2 \rightarrow 2H^+ + NO_3^- + H_2O$$

Fig. 7.1

Establishing a new aquarium

Setting up a new aquarium involves establishing colonies of beneficial bacteria in the tank before fish are added. NH_3 and NH_4^+ are added daily, and the concentrations of different water parameters are monitored.

Fig. 7.2 shows a graph of the water parameters over 35 days.

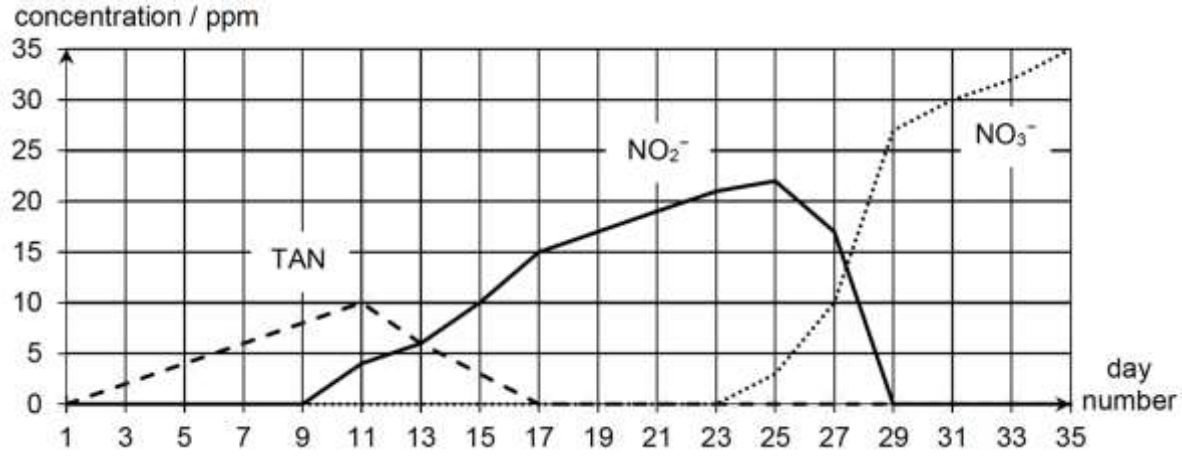


Fig. 7.2

The presence of the respective products in Fig. 7.1 indicates that the beneficial bacteria has been established.

Fish can only be safely added after the concentration of NO_2^- increases then decreases to 0 ppm as NO_2^- is also toxic to fish.

PPM, or parts per million, indicates how many units of a substance are present for every one million units of the total mixture.

Percentage of NH_3 in total ammonia nitrogen (TAN)

The total ammonia nitrogen, TAN, measured is the sum of the concentrations of NH_3 and NH_4^+ present.

The percentage of TAN present as NH_3 is affected by the pH of the aquarium water.

Table 7.3 shows the approximate percentage of TAN present as NH_3 at different pH values.

Table 7.3

pH	% of TAN present as NH_3
6.0	0.4
6.5	1.0
7.0	2.5
7.5	6.3
8.0	16.0
8.5	26.0
9.0	39.0

Measuring dissolved oxygen

The recommended range for the concentration of dissolved oxygen in aquarium water samples is 0.000150 to 0.000500 mol/dm^3.

Manganese is a transition element. In this experiment, manganese(II) hydroxide, $Mn(OH)_2$, is added to aquarium water. Dissolved oxygen in the water oxidises $Mn(OH)_2$ to $Mn(OH)_3$.

The $Mn(OH)_3$ then reacts to produce iodine, I_2. The I_2 is then titrated with thiosulfate ions, $S_2O_3^{2-}$, solution.

It is known that 1 mole of dissolved oxygen produces 4 moles of thiosulfate ions.

(a) Despite nitrification takes place readily under the conditions in an aquarium, the presence of beneficial bacteria is necessary for any appreciable breakdown of NH_3 or NH_4^+ to be observed within a short time.

Suggest the role of beneficial bacteria in the nitrification process.

……..[1]

(b) **(i)** State the day number that first indicates that beneficial bacteria **A** is established.

……..[1]

(ii) State the day number that is first safe for the addition of fish.

……..[1]

(iii) On day 35, 25% of the aquarium water is replaced with water that is free of NO_3^-.

Calculate the new concentration of NO_3^-, in ppm.

[1]

(c) The pH of the aquarium water on Day 11 is measured to be 7.5.

(i) State the value of TAN on Day 11.

……..[1]

(ii) Hence, calculate the concentration of NH_3 present, in ppm, on Day 11.

[1]

(d) A 100 cm^3 of sample of aquarium water containing dissolved oxygen requires 13.40 cm^3 of 0.0100 mol/dm^3 thiosulfate solution to reach the titration end point.

Calculate the concentration of dissolved oxygen in this 100 cm^3 sample and hence determine if it falls within the recommended range.

[3]

(e) State one chemical property of manganese.

……

……..[1]

(f) A student found iron parts in an aquarium filter starting to rust over time. She decides to attach a strip of zinc metal to the iron to prevent rusting.

(i) Name the method used to protect the iron.

……..[1]

(ii) Explain why this method is effective, based on the reactivity series.

……..

……..[1]

[Total: 12]

8 **(a)** Aqueous nickel(II) sulfate, a green solution, is electrolysed using inert platinum electrodes.

During electrolysis, the green colour of the solution fades. Bubbles are observed at one of the electrodes.

Nickel(II) ions, Ni^{2+}, are discharged during this process.

(i) Write the ionic equation for the reaction that occurs at the electrode where Ni^{2+} ions are discharged.

……[1]

(ii) Identify the gas released during this electrolysis and the electrode where it is formed.

gas: ……

electrode: ……..[1]

(iii) Explain why the green colour of the solution fades.

……..

……..[1]

(b) A simple cell is then set up using a nickel strip and a cadmium strip in a beaker of aqueous sodium hydroxide.

The reactivity series shows: Cadmium > Nickel > Hydrogen

(i) Identify which metal is the negative electrode in this cell. Explain your answer.

……..

……..[1]

(ii) State one physical property of nickel and cadmium that make them suitable for use as electrodes in batteries.

……..[1]

(iii) State the direction of electron flow in the external circuit in terms of the metals used.

From …… to …… [1]

(iv) State and explain whether the simple cell will continue to function if the sodium hydroxide electrolyte dries up.

……..

……..

……..[1]

(c) The equation below shows a reaction that occurs in some cells:

$$Mg(s) + 2H^{+}(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$

Show which substance is oxidised using oxidation states.

……..

……..[1]

[Total: 8]

Section B

Answer **one** question from this section.

9 Scientists conducted two experiments to study how different acids and heat affect calcium carbonate.

Experiment 1:

Equal-sized pieces of calcium carbonate were added to aqueous hydrochloric acid, and aqueous ethanoic acid of equal concentration and volume.

(a) (i) Write an equation for the reaction of aqueous ethanoic acid with calcium carbonate.

……[1]

(ii) Explain why the reaction with hydrochloric acid is faster than with ethanoic acid, even though both acids have the same concentration.

……..

……..

……..

……[2]

(iii) The reaction between calcium carbonate and hydrochloric acid is exothermic.

Explain, in terms of bond breaking and bond forming, why the overall enthalpy change for this reaction is negative.

……..

……..

……..

……[2]

(b) Experiment 2:

A separate sample of calcium carbonate was heated strongly in a test tube.

(i) Write an equation for the thermal decomposition reaction.

……[1]

(ii) Explain how the reactivity of calcium and copper affects the thermal decomposition of their respective carbonates.

……..

……..[1]

(c) Crustaceans such as crabs use calcium carbonate to build their shells.

When carbon dioxide dissolves in water, it forms carbonic acid. The following equilibria are established:

Equilibrium 1: $CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

Equilibrium 2: $H_2CO_3(aq) \rightleftharpoons 2H^+ + CO_3^{2-}(aq)$

Table 9.1 shows the concentration of hydrogen ions and carbonate ions in seawater as the amount of dissolved carbon dioxide increases.

Table 9.1

amount of dissolved CO_2	concentration of H^+ / mol/dm^3	concentration of CO_3^{2-} / mol/dm^3
low	1.0×10^{-6}	2.0×10^{-3}
high	1.0×10^{-5}	0.5×10^{-3}

(i) Using the information in Table 9.1, suggest why an increase in dissolved carbon dioxide makes it more difficult for crustaceans to form their shells.

……..

……..[1]

(ii) State the colour change you would expect when Universal Indicator is added to seawater with high dissolved carbon dioxide.

……..[1]

(iii) A student is given a seawater sample and wants to find out if it contains carbonate ions.

Describe a chemical test the student could carry out to confirm the presence of carbonate ions.

……..

……..[1]

[Total: 10]

10 Scientists investigated the chemical behaviour and thermal stability of different carbonates.

(a) Experiment 1:

Samples of sodium carbonate and magnesium carbonate were each added to separate beakers containing equal volumes and concentrations of nitric acid. The rate of gas formation was recorded, and pH measurements were taken before and after excess acid was added.

(i) Write an ionic equation for the reaction between carbonate ions and hydrogen ions.

……[1]

(ii) Sodium carbonate reacts faster than magnesium carbonate.

Explain this observation in terms of solubility and ions availability.

……..

……..

……[1]

(iii) The pH of sodium carbonate solution was 11 before nitric acid was added. After excess nitric acid was added, the pH dropped to 3.

Explain this change in terms of the ions present in the solution and their concentrations.

……..

……..

……[1]

(iv) Predict and explain the difference in the total volume of gas produced when equal masses of sodium carbonate and magnesium carbonate are used, assuming complete reaction.

……..

……..

……..

……[2]

(b) Experiment 2:

A student heated magnesium carbonate and copper(II) carbonate separately in test tubes and observed the temperature at which decomposition began.

(i) Write an equation for the thermal decomposition of magnesium carbonate.

……..[1]

(ii) The gas produced from the thermal decomposition of magnesium carbonate was passed through limewater for a few minutes. A precipitate was initially formed.

Identify the precipitate and state what happens when the gas is passed through limewater for a longer time.

……..

……..

……..[2]

(iii) The decomposition of magnesium carbonate is an endothermic process.

Explain, in terms of bond breaking and bond forming, why the overall enthalpy change for this reaction is positive.

……..

……..

……..

……..[2]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, L = 6.02 x 10^{23} mol^{-1}