RSC TOP OF THE BENCH NATIONAL FINAL 2022

Youngest paper

Name: _____ **School Year:** _____

School: _____

Answer all questions in the spaces provided.

You are provided with a Periodic table.

Write your answers clearly. Show all working.

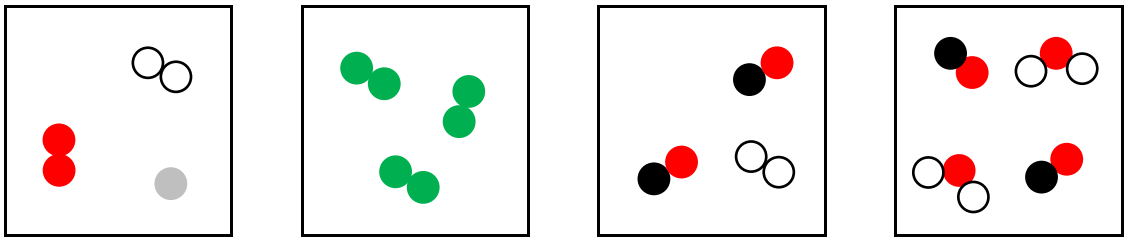
The total marks allocated to the paper are 40 marks (Section A 10 marks, Section B 30 marks)

The time allocated to the paper is 30 minutes.

Scoring: Section A ..... / 10 Section B ..... / 30 **Total** ..... **/ 40**

SECTION A General chemistry knowledge

1.



A **B** **C** **D**

Choose the diagram (**A-D**) that best represents: [2]

a. a pure element **B** b. a mixture of compounds **D**

2. Name the change of state that occurs when a solid changes to a gas without passing through the liquid state. [1]

sublimation

3. Name the element that is the only metal that is a liquid at room temperature. [1]

mercury

4. Name the element which is the most reactive of the halogens. [1]

fluorine

5. Name the separating technique needed to separate each of the following mixtures: [3]

a. Pure water from a solution of salty water (simple) distillation

b. The dyes in a sample of ink chromatography

c. A mixture of liquids with similar boiling points fractional distillation

6. Complete the word equation: [1]

magnesium + oxygen → magnesium oxide

7. State the **two** products from the complete combustion of a hydrocarbon fuel. [1]

carbon dioxide and water (*both needed for the mark*)

SECTION B Questions linked to this year's theme of Sustainable Chemistry

8. This question is about fertilisers.

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As the population of the world increases more food has to be produced on the finite amount of land available.

Plants need water, sunlight and certain chemical elements – nitrogen (N), phosphorus (P) and potassium (K) to grow. They obtain these elements from the soil and the air.

If the plants are harvested as food crops, these elements are lost from the soil.

Fertilisers replace these nutrients in the soil and help to improve crop yield.

a. Fertilisers are made from ammonia.

A molecule of ammonia is shown in **Figure 1.**

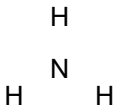


Figure 1

Name the **two** elements in a molecule of ammonia [2]

nitrogen [1] / hydrogen [1]

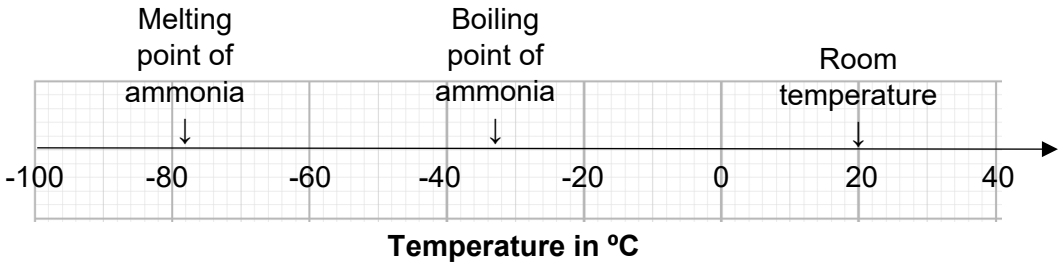


Figure 2

Figure 2 gives the melting point and boiling point of ammonia.

b. Using the information in **Figure 2** circle the state of ammonia at room temperature. [1]

solid **liquid** **gas**

Ammonia, NH_3 is made by reacting nitrogen, N_2 with hydrogen, H_2.

c. i. Balance the symbol equation for the reaction shown below: [1]

$N_2 + 3\ H_2$ Ý $2\ NH_3$ *(ignore the addition of 1 before N_2)*

ii. What does the symbol Ý tell you about this reaction? [1]

The reaction is reversible / products convert back into reactants / it goes in both directions

Figure 3 below shows how the percentage conversion to ammonia changes with temperature and pressure.

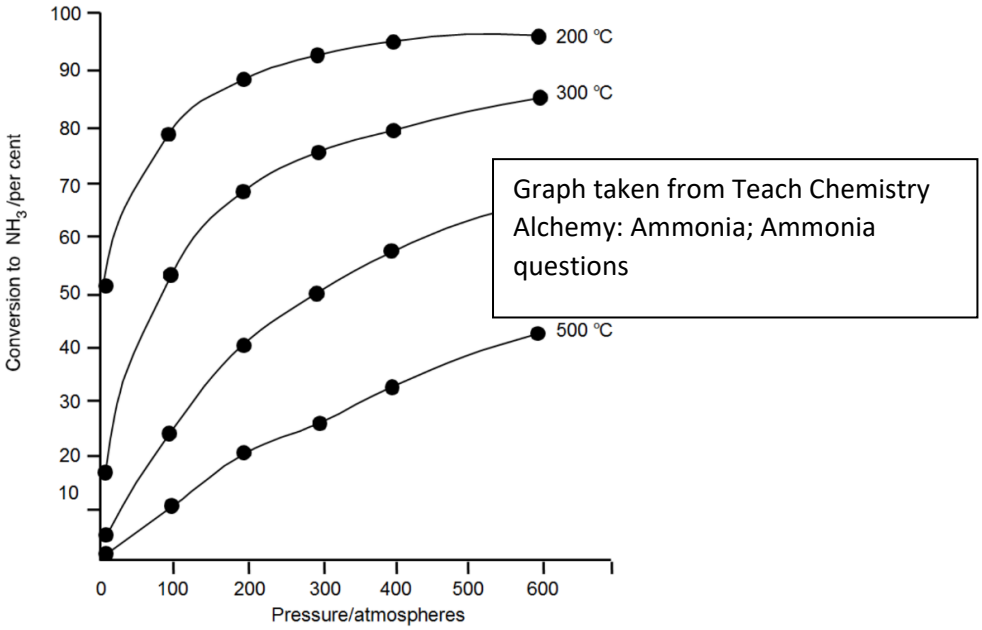


Figure 3

d. Use **Figure 3** to identify the conditions that give the highest percentage conversion. [1]

	High temperature and high pressure
	High temperature and low pressure
x	Low temperature and high pressure
	Low temperature and low pressure

e. An iron catalyst is also used in this reaction.

i. Describe the role of a catalyst in a chemical reaction. [2]

[1] Speeds up a reaction

[1] Chemically unchanged / without being used up in the reactions

ii. Explain why finding a suitable catalyst is important for industrial processes. [1]

Any one from

- Increase the amount of product produces in a set time / per day
- Reduce the cost by lowering the reaction temperature

In order to be absorbed by the crop's roots, the ammonia must be converted into a soluble salt by reacting it with an acid. This is the fertiliser:

ammonia + acid → soluble salt (**fertiliser**)

A company wishes to make a fertiliser containing the soluble salt, **ammonium nitrate.**

f. i. Circle the name of the acid ammonia must be reacted with to make ammonium nitrate. [1]

hydrochloric acid **sulfuric acid** **nitric acid** **phosphoric acid**

ii. Identify the type of reaction used: [1]

- [ ] thermal decomposition
- [x] neutralisation
- [ ] displacement

Question 8 continues on the next page

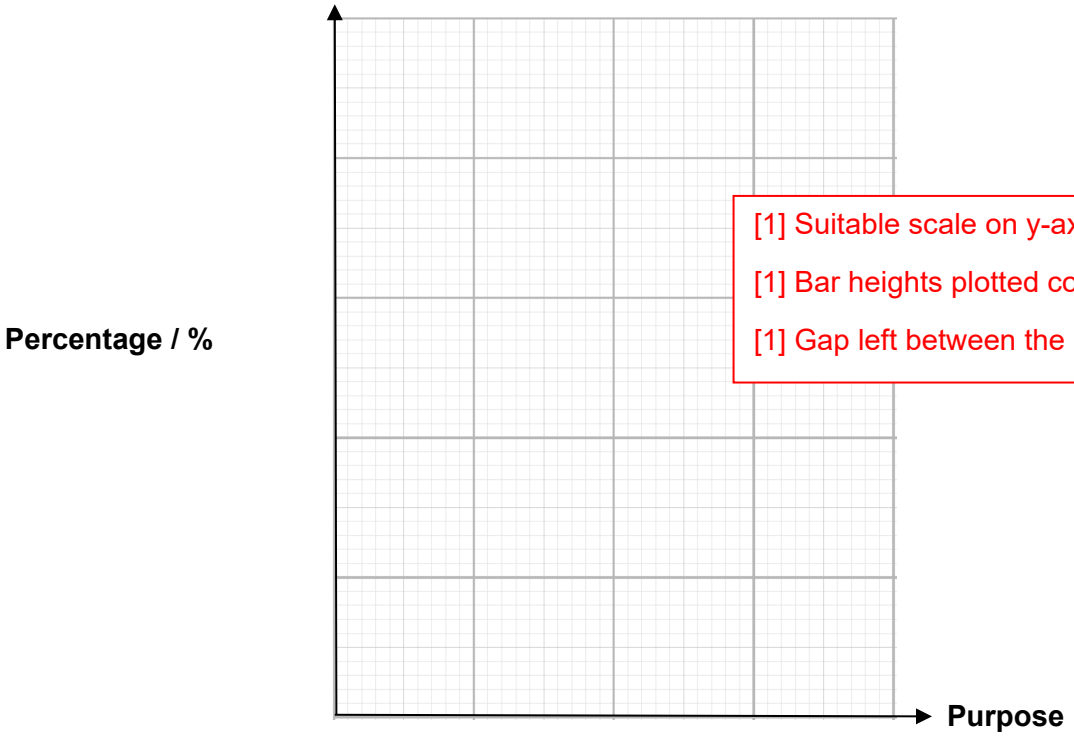
Not all the ammonia produced globally is used to make fertilisers. **Table 1** shows the percentage amount of fertiliser used for different purposes.

Purpose	Percentage
Making fertilisers	80%
Making other chemicals and wool pulp	8%
Making nylon	7%
Making nitric acid	5%

Data taken from Teach Chemistry Alchemy: Ammonia; Ammonia fact file

Table 1 Percentage amount of ammonia used for different purposes

g. i. Represent this data as a **bar chart** on the axes below. [3]



[1] Suitable scale on y-axis

[1] Bar heights plotted correctly

[1] Gap left between the bars

ii. If the annual global production of ammonia is 176 million tonnes per year, calculate the mass of ammonia **in kg** that is used to produce fertilisers each year. [2]

(1 tonne = 1000 kilograms)

(80 / 100) × 176 000 000 tonnes = 140 800 000 tonnes [1]

140 800 000 tonnes × 1000 = 1.408×10^{11} kg or 140 800 000 000 kg [1]

Correct answer with no working = 2 marks

9. This question is about the metal, copper.

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a. A major use of copper is for electrical wiring.

Identify the **two** properties of copper from the list below that make it useful for electrical wiring. [2]

- [x] Good electrical conductivity
- [ ] Good thermal conductivity
- [x] Ductile
- [ ] Lustrous

b. Copper exists as two isotopes, 63-copper $^{63}_{29}Cu$ and 65-copper $^{65}_{29}Cu$

State **in terms of subatomic particles** what makes these atoms isotopes of the element copper. [2]

[1] Both contain the same number / 29 protons

[1] Each contains different numbers of neutrons (63-Cu 24 neutrons; 65-Cu 26 neutrons)

Copper can be found in rocks underground in the mineral malachite.

Malachite contains copper carbonate, $CuCO_3$ which has a distinctive green colour.

c. Copper carbonate undergoes thermal decomposition to produce black copper oxide, CuO and carbon dioxide, CO_2.

i. Write a balanced symbol equation for this reaction. [1]

$CuCO_3 \rightarrow CuO + CO_2$

ii. State if this reaction, an example of a thermal decomposition reaction, is endothermic or exothermic. [1]

endothermic **exothermic**

A student investigated the thermal decomposition of a sample of copper carbonate.

Figure 4 shows the apparatus they used.

Table 2 shows their results.

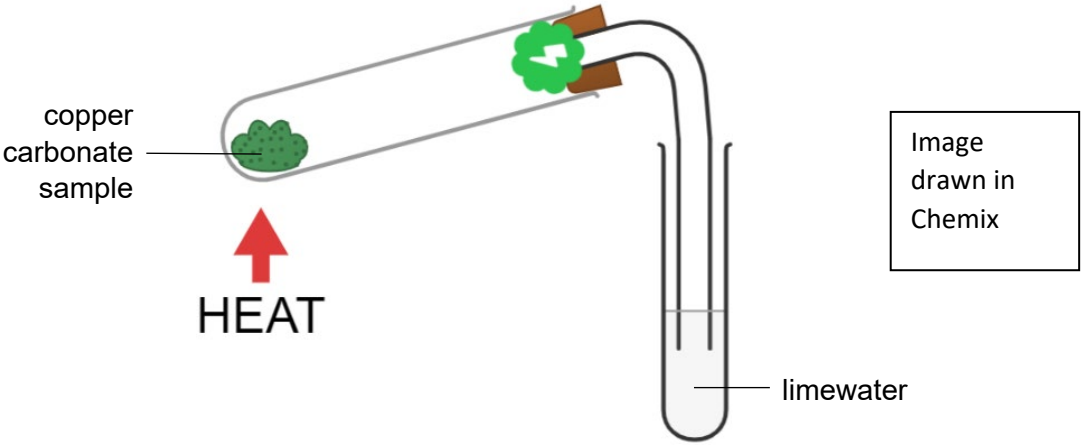

Figure 4

Mass of test tube and copper carbonate before heating in g	Mass of test tube and solids after 5 min of heating in g	Observations	
		Changes observed in the colour of the solid	Changes observed in the limewater
25.65	22.25	[1] Green solid to black solid	[1] Limewater turns cloudy (allow milky)

Table 2

d. i. Explain the change in mass observed after heating the copper carbonate for 5 minutes.

[1] Mass decreases / goes down on heating

[1] owing to carbon dioxide product escaping the flask / carbon dioxide product is a gas

ii. Complete **Table 2** by describing the changes that would be observed to both the solid and the limewater. [2]

In the early days of commercial mining, miners extracted malachite from the ground and used it as a source of pure copper.

potassium	K
sodium	Na
calcium	Ca
magnesium	Mg
aluminium	Al
carbon	*(non metal)*
zinc	Zn
iron	Fe
lead	Pb
hydrogen	*(non-metal)*
copper	Cu
silver	Ag
gold	Au

The reactivity series

e. Using **the reactivity series**, explain why copper can be extracted from copper carbonate by heating with carbon. [2]

[1] carbon is more reactive / higher up the reactivity series than copper

[1] so will displace copper from the copper carbonate (word displace required for mark)

In order to continue to use copper as sustainably as possible it is important to continue to recycle as much as we can.

Currently 34% of the global annual amount of copper used is recycled.

f. If in 2020, 8 495 580 tonnes of copper was recycled, calculate the annual global production of copper. [2]

8 495 580 tonnes = 34 %

so 100 % = (8 495 580 / 34) × 100 = 24 987 000 tonnes

(one mark for working; one mark for answer)