



**BEATTY SECONDARY SCHOOL  
PRELIMINARY EXAMINATION 2022  
SECONDARY FOUR EXPRESS**

CANDIDATE  
NAME

CLASS

REGISTER  
NUMBER

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**CHEMISTRY**

Paper 1

Multiple Choice

Setter:

Mr Yeo Chee Keong

**6092/01**

**31 August 2022**

**1 hour**

Additional Materials:

Multiple Choice Answer Sheet

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**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, class and register number on the Multiple Choice Answer Sheet provided.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers, **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

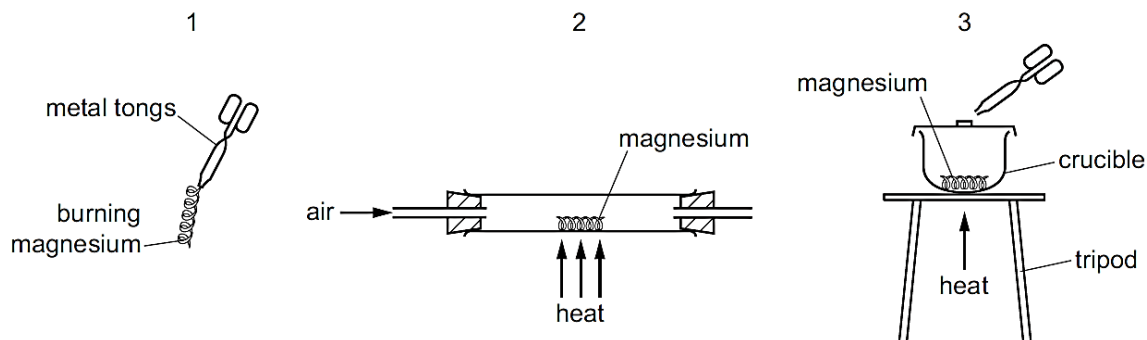
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

A copy of the Periodic Table is printed on page 15.

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

- 1 Shermen investigates the change in mass during the combustion of magnesium. The diagrams show three set-ups for this investigation.



Which set-up(s) is/are suitable for this investigation?

- A 3 only  
 B 1 and 3 only  
 C 2 and 3 only  
 D 1, 2 and 3 only
- 2 The table shows the observations made when different reagents are added to an aqueous solution of Z.

| reagents added                                        | observations                                                               |
|-------------------------------------------------------|----------------------------------------------------------------------------|
| aqueous sodium hydroxide                              | green-white precipitate; green precipitate only in excess sodium hydroxide |
| dilute nitric acid followed by aqueous silver nitrate | yellow precipitate                                                         |
| dilute nitric acid followed by aqueous barium nitrate | no visible reaction                                                        |

What are the ions present in solution Z?

- A  $Al^{3+}$ ,  $Fe^{2+}$ ,  $I^{-}$   
 B  $Al^{3+}$ ,  $Fe^{3+}$ ,  $SO_4^{2-}$   
 C  $Pb^{2+}$ ,  $Fe^{2+}$ ,  $I^{-}$   
 D  $Pb^{2+}$ ,  $Fe^{3+}$ ,  $Cl^{-}$
- 3 A mixture of colourless amino acids is separated using chromatography. The solvent used is propanol and the chromatogram is sprayed with a locating agent.

Which row describes the purpose of the propanol and the locating agent?

|   | purpose of propanol                                    | purpose of locating agent                     |
|---|--------------------------------------------------------|-----------------------------------------------|
| A | to make the individual amino acids visible             | to prevent the amino acids moving any further |
| B | to move the amino acids up the chromatography paper    | to make the individual amino acids visible    |
| C | to move the amino acids up the chromatography paper    | to prevent the amino acids moving any further |
| D | to prevent the amino acids moving too far up the paper | to make the individual amino acids visible    |

- 4 How many underlined substance(s) can be obtained by fractional distillation of the mixture?

- hydrogen from liquefied air
- propene from bitumen
- ethanol from water and ethanol mixture
- ethyl ethanoate from ethanol and ethanoic acid

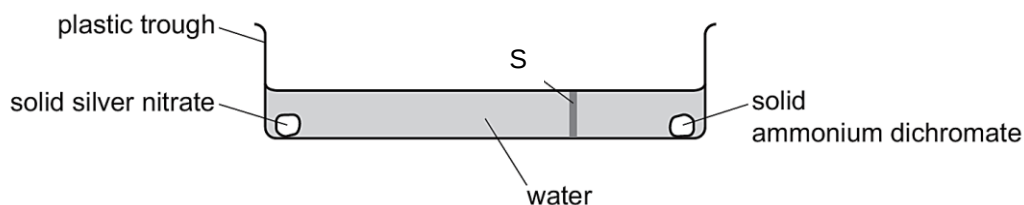
A 1

B 2

C 3

D 4

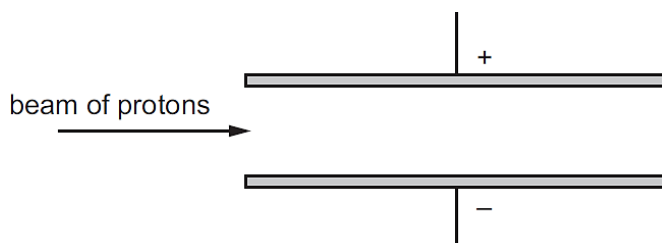
- 5 Silver dichromate is a red solid that can be made by reacting silver nitrate solution with ammonium dichromate solution. The apparatus was set up as shown.



After five minutes, a red solid appeared along the line marked 'S' on the diagram.

What conclusion can be made from this experiment?

- A Diffusion of silver nitrate occurs faster than the diffusion of ammonium dichromate.  
 B Silver ions have a lower relative molecular mass than dichromate ions.  
 C Solid silver nitrate is more soluble than solid ammonium dichromate.  
 D The red solid formed would dissolve to form a coloured solution.
- 6 A beam of protons was passed through an electrostatic field between two charged plates. The electrostatic field deflected the beam of protons. The lower the relative mass of the particle, the larger the deflection.

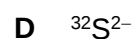
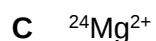
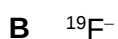
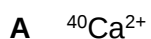


The experiment was repeated using a beam of electrons in place of the beam of protons.

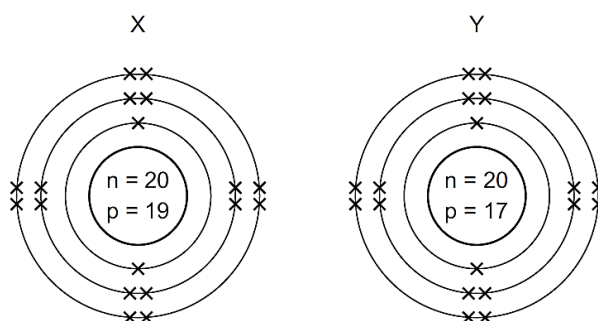
Which row correctly shows the amount and direction of the beam of electrons?

|   | amount of deflection of beam of electrons | direction of deflection of beam of electrons |
|---|-------------------------------------------|----------------------------------------------|
| A | deflected less than beam of protons       | opposite direction to beam of protons        |
| B | deflected less than beam of protons       | same direction as beam of protons            |
| C | deflected more than beam of protons       | opposite direction to beam of protons        |
| D | deflected more than beam of protons       | same direction as beam of protons            |

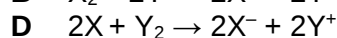
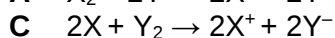
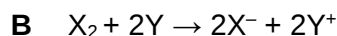
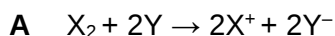
7 Which ion contains the same number of both neutrons and electrons?



8 The arrangements of the electrons in two ions formed from elements X and Y are shown.



Which equation represents the reaction between elements X and Y?



9 Magnesium oxide may be used for the lining of an electric furnace for making crockery.

Which properties of magnesium oxide help to explain this use?

|   | ionic bonding | electrical conductivity | solubility in water |
|---|---------------|-------------------------|---------------------|
| A | no            | yes                     | no                  |
| B | no            | no                      | yes                 |
| C | yes           | yes                     | yes                 |
| D | yes           | no                      | no                  |

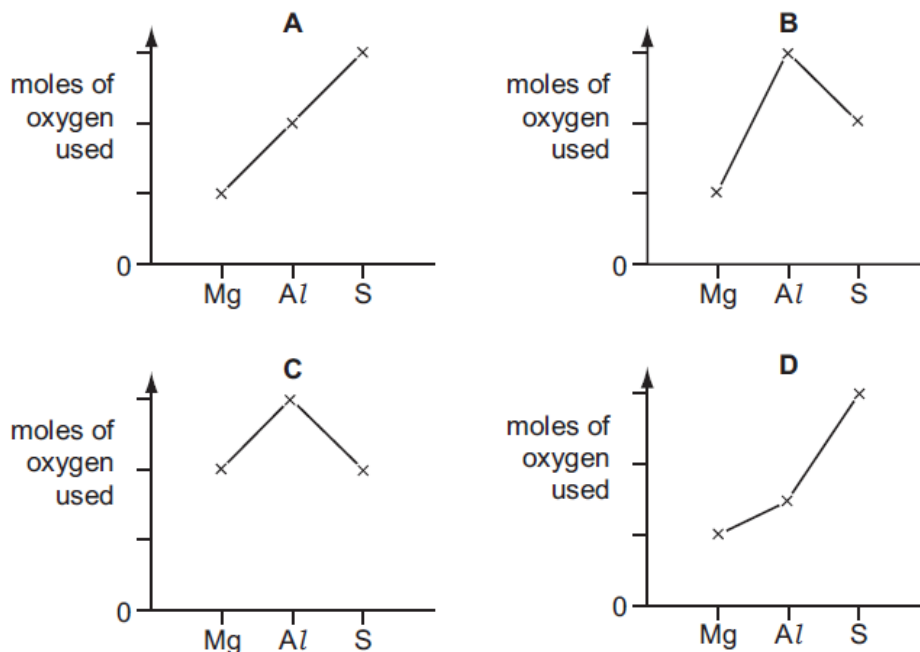
10 Both aluminium and graphite are good conductors of electricity and have high melting points.

Which row correctly shows the similarity and difference between aluminium and graphite?

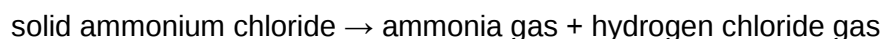
|   | similarity                                             | difference                                                                                                                                  |
|---|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| A | good conductors of electricity due to mobile electrons | aluminium has a high melting point due to strong metallic bonds while graphite has a high melting point due to strong intermolecular forces |
| B | good conductors of electricity due to mobile electrons | aluminium has a high melting point due to strong metallic bonds while graphite has a high melting point due to strong covalent bonds        |
| C | high melting point due to strong forces of attraction  | aluminium conducts electricity due to positive cations while graphite conducts electricity due to mobile electrons                          |
| D | high melting point due to strong forces of attraction  | aluminium conducts electricity due to sea of delocalised electrons while graphite conducts electricity due to oppositely charged ions       |

- 11 One mole of magnesium, aluminium and sulfur are each completely burned in excess of oxygen gas.

Which graph shows the number of moles of oxygen used for each element?



- 12 A sample of solid ammonium chloride decomposes on heating.



A total of  $2.4 \times 10^{21}$  molecules of gas is formed.

What is the volume of ammonia gas produced?

- A** 48 cm<sup>3</sup>      **B** 96 cm<sup>3</sup>      **C**  $2.88 \times 10^{25}$  cm<sup>3</sup>      **D**  $5.76 \times 10^{25}$  cm<sup>3</sup>
- 13 62 g of impure copper(II) carbonate undergoes thermal decomposition to produce 10 dm<sup>3</sup> of carbon dioxide gas.

What is the percentage purity of copper(II) carbonate?

[M<sub>r</sub>: CuCO<sub>3</sub>, 124]

- A** 16.1%      **B** 50.0%      **C** 83.3%      **D** 92.0%
- 14 In an electrolysis experiment, the same amount of charge deposited 12 g of titanium and 32 g of copper. The charge on the copper ion was 2+.

[A<sub>r</sub>: Ti, 48; Cu, 64]

What was the charge on the titanium ion?

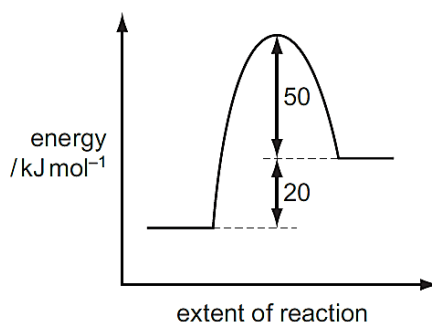
- A** 1+      **B** 2+      **C** 3+      **D** 4+

15 Concentrated aqueous sodium chloride is electrolysed using inert electrodes.

Which row correctly explains the change occurring during electrolysis?

|   | change occurring                                                                       | explanation                                                            |
|---|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| A | oxygen is liberated at the positive electrode                                          | $\text{OH}^-$ ions loses electrons more easily than $\text{Cl}^-$ ions |
| B | pH of the electrolyte increases                                                        | $\text{H}^+$ ions are discharged                                       |
| C | products of electrolysis stay the same when molten sodium chloride electrolyte is used | $\text{Na}^+$ and $\text{Cl}^-$ ions are present in both electrolytes  |
| D | solid sodium is deposited at the negative electrode                                    | $\text{Na}^+$ ions are discharged                                      |

16 The reaction pathway for a reversible reaction is shown.



Which statements about the reaction are correct?

- 1 The activation energy for the forward reaction is +70 kJ/mol.
- 2 The enthalpy change for the backward reaction is  $-50$  kJ/mol.
- 3 The shape of the graph can be represented by the decomposition of silver salts in photographic films by light.
- 4 The shape of the graph can be represented by the dissolution of ammonium nitrate in water.

- A 1 and 2 only  
C 3 and 4 only

- B 2 and 3 only  
D 1 and 4 only

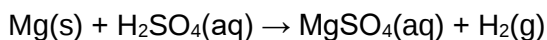
17 Qiyang investigates the effect of concentration on the rate of reaction between calcium carbonate and hydrochloric acid. He follows the method shown.

- Place 1 g of calcium carbonate in a conical flask.
- Add excess hydrochloric acid.
- Let the reaction continue until no more gas is produced.
- Repeat the experiment with different concentrations of hydrochloric acid.

Which essential step has been left out of the method if he is to work out the rate of the reaction?

- A placing a rubber bung in the conical flask  
B placing the experiment setup onto an electronic balance  
C plotting a graph to calculate the gradient  
D using a stopwatch to time the reaction

- 18 Magnesium reacts with dilute sulfuric acid.



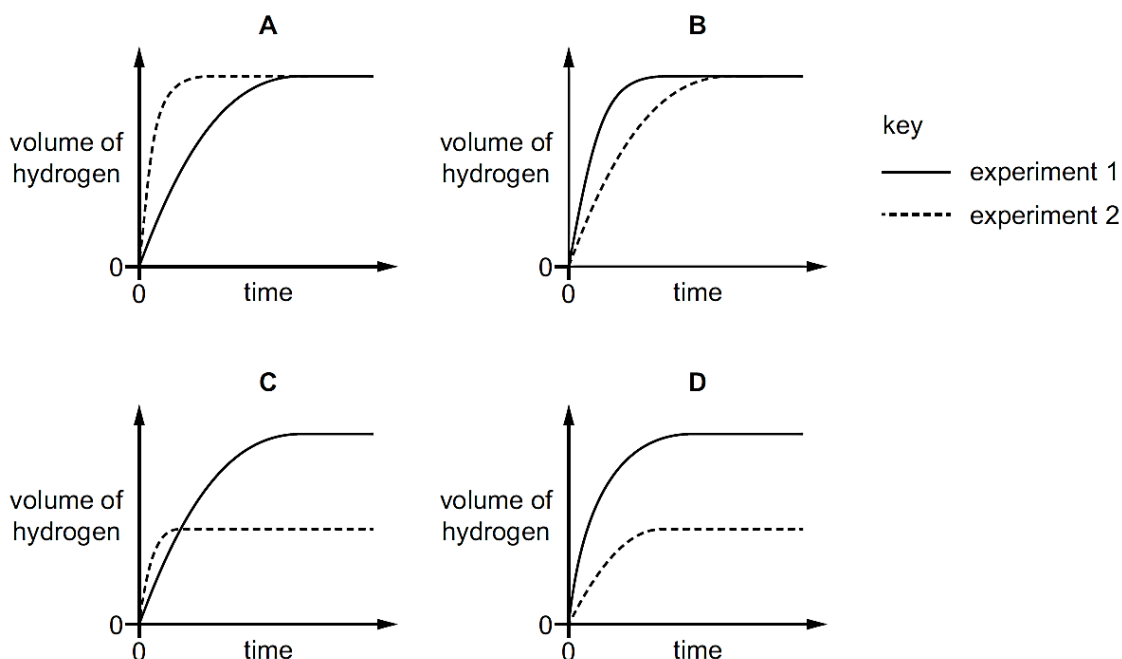
Two experiments were carried out.

experiment 1: 24.0 g of magnesium reacted with 100 cm<sup>3</sup> of 1.0 mol/dm<sup>3</sup> sulfuric acid.

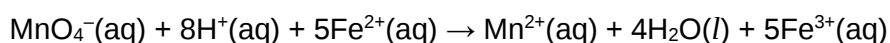
experiment 2: 24.0 g of magnesium reacted with 50 cm<sup>3</sup> of 2.0 mol/dm<sup>3</sup> sulfuric acid.

In each experiment the volume of hydrogen was measured at various times. The results were plotted on a graph.

Which graph is correct?



- 19 Acidified  $\text{MnO}_4^-$  is often used in titrations to determine the concentrations of other solutions. One such reaction is represented by the ionic equation shown.



Which statement is correct?

- A Eight moles of  $\text{H}^+$  ions are oxidised by gaining 4 moles of oxygen atoms.
  - B Five moles of  $\text{Fe}^{2+}$  ions are oxidised by losing 5 moles of electrons.
  - C Manganese is oxidised in the process as the oxidation state increases.
  - D This is not a redox reaction as the number of hydrogen atoms remain unchanged.
- 20 The thermal decomposition of one mole of ammonium nitrate gives only two products: two moles of steam and one mole of an oxide of nitrogen, X.

What is the oxidation state of nitrogen in X?

- A +1
- B +2
- C +3
- D +4

- 21 Acids are used in many chemical reactions.

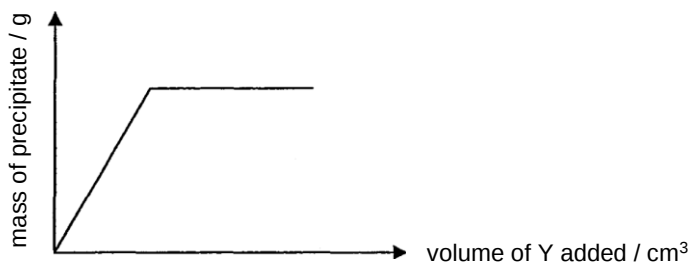
Which row correctly shows the role of acid in the reaction mixture?

|          | reaction mixture                                      | role of acid    |
|----------|-------------------------------------------------------|-----------------|
| <b>A</b> | ethanoic acid, ethanol and concentrated sulfuric acid | catalyst        |
| <b>B</b> | ethanol, potassium manganate(VII) and nitric acid     | oxidising agent |
| <b>C</b> | lead(II) carbonate and phosphoric acid                | precipitation   |
| <b>D</b> | lead(II) nitrate and sulfuric acid                    | neutralisation  |

- 22 Which statement about oxides is correct?

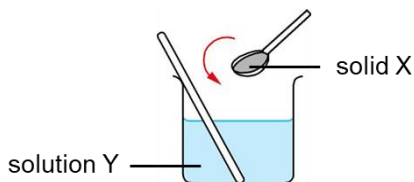
- A** A solution of magnesium oxide has a pH less than 7.  
**B** A solution of sulfur dioxide has a pH greater than 7.  
**C** Magnesium oxide reacts with nitric acid to produce a salt.  
**D** Sulfur dioxide reacts with hydrochloric acid to produce a salt.

- 23 An aqueous solution of X was placed in a test tube and an aqueous solution of Y gradually added from a burette. The mass of the precipitate was obtained as shown.



Which pair of reagents are possible identities of X and Y?

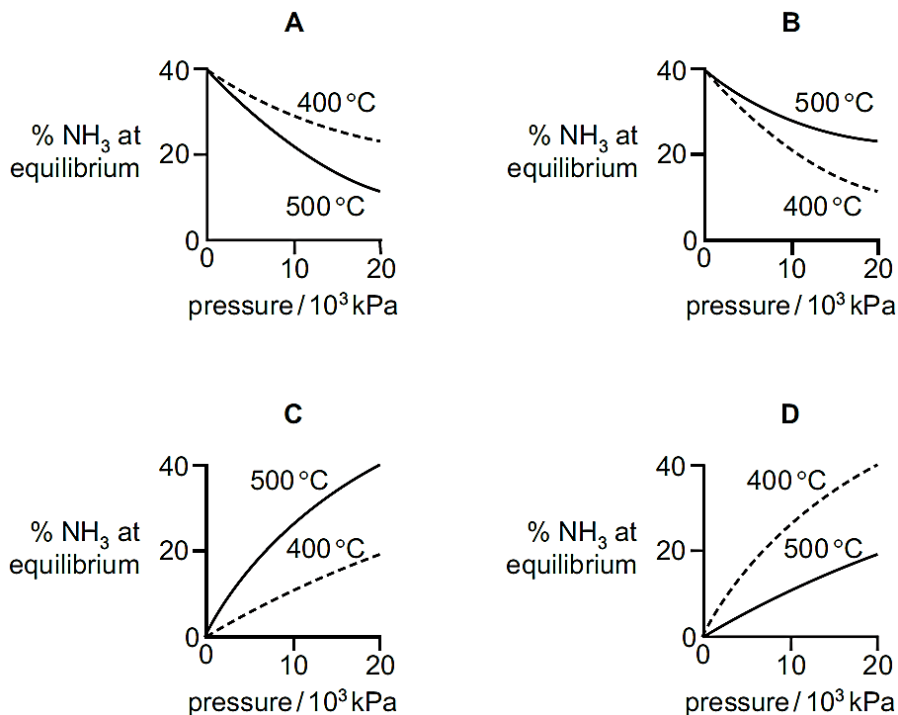
- A** ammonia solution and zinc chloride      **B** calcium hydroxide and nitric acid  
**C** magnesium carbonate and water      **D** sodium carbonate and barium nitrate
- 24 A student wishes to prepare a pure and dry sample of copper(II) nitrate using the method shown in the diagram.



Which row correctly shows the identity of solid X and solution Y used?

|          | solid X                     | solution Y         |
|----------|-----------------------------|--------------------|
| <b>A</b> | copper(II) chloride         | excess nitric acid |
| <b>B</b> | copper(II) hydroxide        | excess nitric acid |
| <b>C</b> | excess copper               | nitric acid        |
| <b>D</b> | excess copper(II) carbonate | nitric acid        |

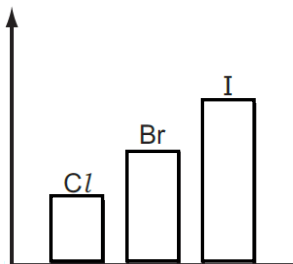
- 25 Which diagram best represents the percentage of ammonia formed at different temperatures and pressures?



- 26 Which statement about the elements in the Periodic Table is correct?

- A All the Group 0 elements cannot form compounds.
- B Elements in Group V form ions with a charge of 5+.
- C Elements in the same group react in a similar way because they all contain the same number of electrons.
- D Germanium has a less metallic character than gallium.

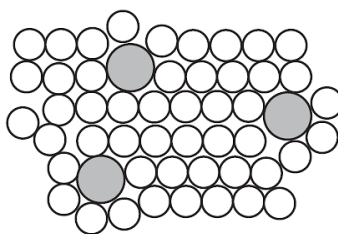
- 27 Kendrick drew a bar chart representing the properties of some Group VII elements.



Which properties follow the trend observed in the bar chart?

- 1 colour intensity
  - 2 melting point
  - 3 oxidising ability
  - 4 reactivity
- A 1 and 2 only                      B 2 and 3 only  
C 3 and 4 only                    D 1 and 4 only

- 28 The diagram shows the structure of an alloy.



Which statement about alloys is correct?

- A All alloys contain iron atoms.  
 B Alloys can only be formed by mixing copper or iron with other metals.  
 C High carbon steel alloys are soft and easily shaped.  
 D There are forces of attraction between the positive ions and 'sea of electrons'.
- 29 Abby carried out some experiments to place four metals, P, Q, R, and S in order of reactivity. The results are as shown.

|                       | metal P | metal Q | metal R | metal S |
|-----------------------|---------|---------|---------|---------|
| solution of P nitrate | —       | ✗       | ✗       | ✗       |
| solution of Q nitrate | ✓       | —       | ✓       | ✓       |
| solution of R nitrate | ✓       | ✗       | —       | ✓       |
| solution of S nitrate | ✓       | ✗       | ✗       | —       |

**Key** ✓ shows a reaction happened  
 ✗ shows no reaction happened  
 — shows the experiment was not performed

What is the correct order of reactivity of the four metals?

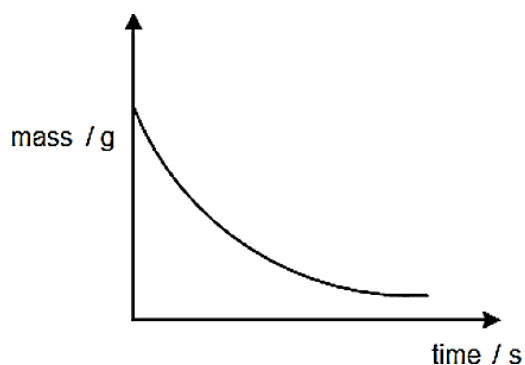
|          | most reactive  least reactive |   |   |   |
|----------|------------------------------------------------------------------------------------------------------------------|---|---|---|
| <b>A</b> | P                                                                                                                | Q | R | S |
| <b>B</b> | P                                                                                                                | S | R | Q |
| <b>C</b> | Q                                                                                                                | R | S | P |
| <b>D</b> | Q                                                                                                                | P | S | R |

- 30 Metal X is more reactive than zinc but less reactive than sodium.

What would be the best method for obtaining metal X from its ore?

- A electrolysis of an aqueous solution of a salt of X  
 B electrolysis of the molten oxide of X  
 C heating the oxide of X in hydrogen  
 D heating the oxide of X with powdered carbon

- 31 A known mass of unknown carbonate was placed in an open crucible and heated until there was no further change observed. The results are as shown.



Which carbonates will give the results as shown?

- 1 calcium carbonate
- 2 hydrated potassium carbonate
- 3 sodium carbonate
- 4 zinc carbonate

- A** 1 and 3 only  
**C** 1 and 4 only

- B** 2 and 3 only  
**D** 1, 2 and 4 only

- 32 A steel bicycle which had been left outdoors for several months was starting to rust.

What would **not** reduce the rate of corrosion?

- A** Add acid to the rust and paint the bicycle.  
**B** Paint the bicycle and wipe the bicycle with an oily cloth.  
**C** Store the bicycle in a dry shed.  
**D** Wipe the bicycle with a clean, damp cloth and oil the bicycle.

- 33 Four sources of air pollution are listed.

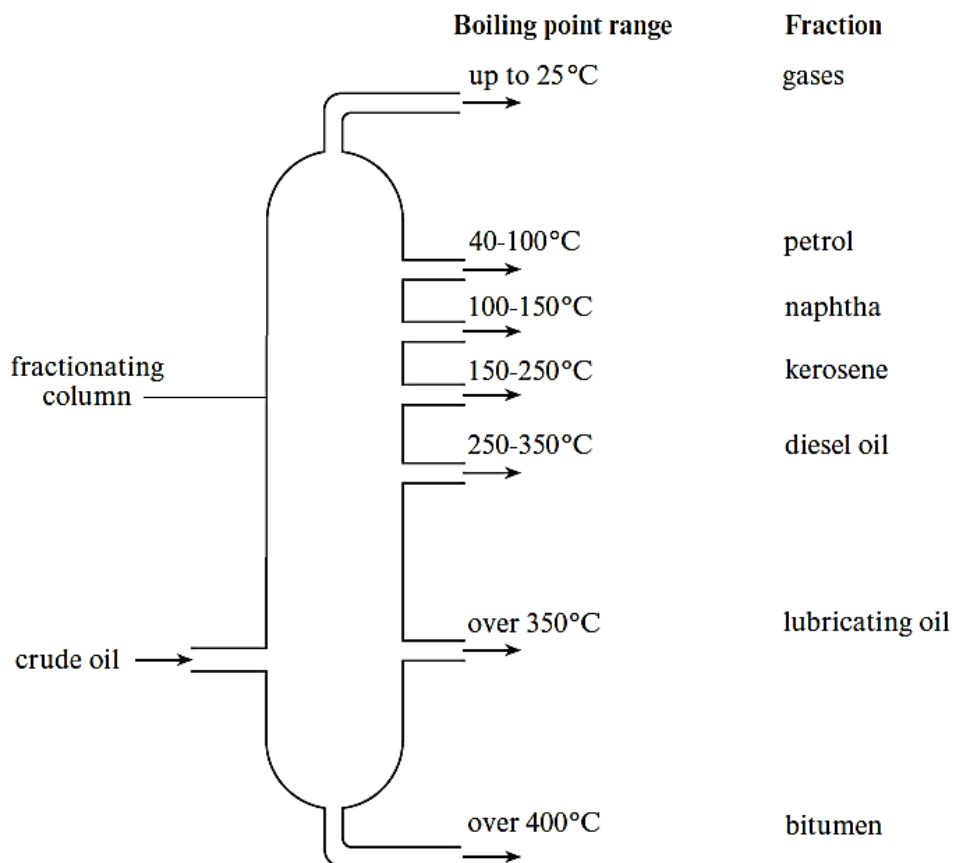
- 1 burning coal
- 2 internal combustion in car engines
- 3 incomplete combustion of carbon-containing fuels
- 4 adding lead compounds to petrol

Which sources produce acid rain?

- A** 1 and 2 only  
**C** 2 and 3 only

- B** 1 and 3 only  
**D** 3 and 4 only

**34** Crude oil is separated into fractions in the fractionating column as shown.



Which statements about the separation of crude oil are correct?

- 1 A mixture of octane and nonane can be found in the petrol fraction.
- 2 All the fractions belong to the same homologous series with an increasing boiling point down the column.
- 3 The molecular masses of the fractions increase down the column.

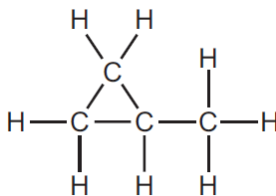
**A** 3 only

**B** 1 and 3 only

**C** 2 and 3 only

**D** 1, 2 and 3

**35** The diagram shows the structural formula of an organic compound.



Which statement about this compound is correct?

**A** It has a general formula of  $\text{C}_n\text{H}_{2n+2}$ .

**B** It is a saturated hydrocarbon.

**C** It is an isomer of butane.

**D** It is formed from the hydrogenation of butene.

36 Which equation represents the complete combustion of an organic molecule with a relative molecular mass of 32?

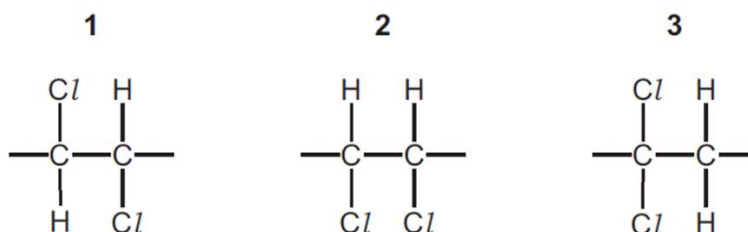
- A  $\text{CH}_3\text{NH}_3 + 3\text{O}_2 \rightarrow \text{CO}_2 + 3\text{H}_2\text{O} + \text{NO}$   
 B  $2\text{CH}_4 + 4\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$   
 C  $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$   
 D  $2\text{HCO}_2\text{H} + \text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$

37 Which row correctly shows the products obtained by cracking of hydrocarbons?

|   | alkene | hydrogen | water |
|---|--------|----------|-------|
| A | ✓      | ✗        | ✗     |
| B | ✓      | ✓        | ✗     |
| C | ✓      | ✓        | ✓     |
| D | ✗      | ✓        | ✓     |

38 A mixture of the three isomers of  $\text{C}_2\text{H}_2\text{Cl}_2$  is polymerised.

Three repeating units of the possible polymers are shown.



Which repeating units could be seen within the polymer chains?

- A 1 and 2 only  
 B 1 and 3 only  
 C 2 and 3 only  
 D 1, 2 and 3

39 Several reagents are listed below.

- aqueous bromine
- ethanol
- magnesium
- potassium manganate(VII)
- Universal Indicator

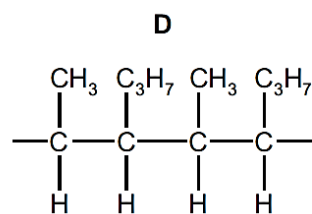
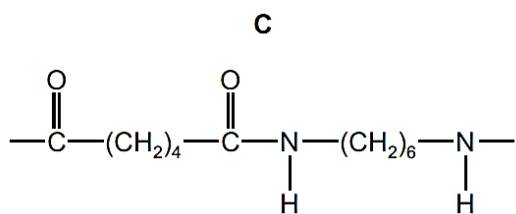
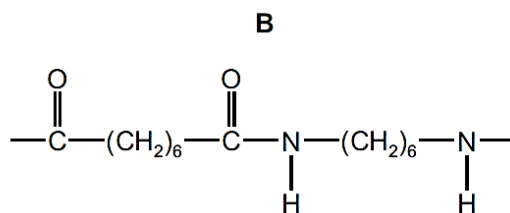
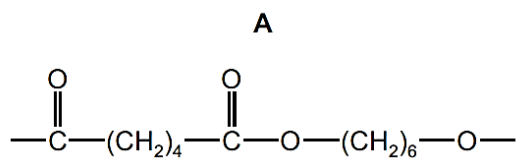
How many reagents can be used to physically distinguish separate beakers of propanol and propanoic acid?

- A 2                      B 3                      C 4                      D 5

40 P is a polymer that

- has six carbon atoms in each of the monomers from which it was formed,
- has a similar structure to nylon,
- was formed from the loss of water molecules.

What is the partial structure of P?



# The Periodic Table of Elements

| Group                      |                             |                                                                                                      |                             |                             |                              |                              |                              |                             |                              |                            |                            |                              |                                |                               |                               |                             |                             |                            |                               |                           |                        |
|----------------------------|-----------------------------|------------------------------------------------------------------------------------------------------|-----------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|-----------------------------|------------------------------|----------------------------|----------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|----------------------------|-------------------------------|---------------------------|------------------------|
| I                          | II                          | 1<br>H<br>hydrogen<br>1                                                                              |                             |                             |                              |                              |                              |                             |                              |                            |                            | III                          | IV                             | V                             | VI                            | VII                         | 0                           |                            |                               |                           |                        |
|                            |                             | <div>Key</div> <div>proton (atomic) number<br/>atomic symbol<br/>name<br/>relative atomic mass</div> |                             |                             |                              |                              |                              |                             |                              |                            |                            |                              |                                |                               |                               |                             |                             |                            |                               |                           |                        |
| 3<br>Li<br>lithium<br>7    | 4<br>Be<br>beryllium<br>9   |                                                                                                      |                             |                             |                              |                              |                              |                             |                              |                            |                            |                              |                                |                               |                               |                             |                             |                            |                               |                           |                        |
| 11<br>Na<br>sodium<br>23   | 12<br>Mg<br>magnesium<br>24 | 13<br>Al<br>aluminium<br>27                                                                          | 14<br>Si<br>silicon<br>28   | 15<br>P<br>phosphorus<br>31 | 16<br>S<br>sulfur<br>32      | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40      |                             |                              |                            |                            |                              |                                |                               |                               |                             |                             |                            |                               |                           |                        |
| 19<br>K<br>potassium<br>39 | 20<br>Ca<br>calcium<br>40   | 21<br>Sc<br>scandium<br>45                                                                           | 22<br>Ti<br>titanium<br>48  | 23<br>V<br>vanadium<br>51   | 24<br>Cr<br>chromium<br>52   | 25<br>Mn<br>manganese<br>55  | 26<br>Fe<br>iron<br>56       | 27<br>Co<br>cobalt<br>59    | 28<br>Ni<br>nickel<br>59     | 29<br>Cu<br>copper<br>64   | 30<br>Zn<br>zinc<br>65     | 31<br>Ga<br>gallium<br>70    | 32<br>Ge<br>germanium<br>73    | 33<br>As<br>arsenic<br>75     | 34<br>Se<br>selenium<br>79    | 35<br>Br<br>bromine<br>80   | 36<br>Kr<br>krypton<br>84   |                            |                               |                           |                        |
| 37<br>Rb<br>rubidium<br>85 | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89                                                                             | 40<br>Zr<br>zirconium<br>91 | 41<br>Nb<br>niobium<br>93   | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>-  | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103  | 46<br>Pd<br>palladium<br>106 | 47<br>Ag<br>silver<br>108  | 48<br>Cd<br>cadmium<br>112 | 49<br>In<br>indium<br>115    | 50<br>Sn<br>tin<br>119         | 51<br>Sb<br>antimony<br>122   | 52<br>Te<br>tellurium<br>128  | 53<br>I<br>iodine<br>127    | 54<br>Xe<br>xenon<br>131    |                            |                               |                           |                        |
| 55<br>Cs<br>caesium<br>133 | 56<br>Ba<br>barium<br>137   | 57 – 71<br>lanthanoids                                                                               |                             |                             |                              |                              | 72<br>Hf<br>hafnium<br>178   | 73<br>Ta<br>tantalum<br>181 | 74<br>W<br>tungsten<br>184   | 75<br>Re<br>rhenium<br>186 | 76<br>Os<br>osmium<br>190  | 77<br>Ir<br>iridium<br>192   | 78<br>Pt<br>platinum<br>195    | 79<br>Au<br>gold<br>197       | 80<br>Hg<br>mercury<br>201    | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207     | 83<br>Bi<br>bismuth<br>209 | 84<br>Po<br>polonium<br>-     | 85<br>At<br>astatine<br>- | 86<br>Rn<br>radon<br>- |
| 87<br>Fr<br>francium<br>-  | 88<br>Ra<br>radium<br>-     | 89 – 103<br>actinoids                                                                                |                             |                             |                              |                              | 104<br>Rf<br>Rutherfordium   | 105<br>Db<br>dubnium<br>-   | 106<br>Sg<br>seaborgium<br>- | 107<br>Bh<br>bohrium<br>-  | 108<br>Hs<br>hassium<br>-  | 109<br>Mt<br>meitnerium<br>- | 110<br>Ds<br>darmstadtium<br>- | 111<br>Rg<br>roentgenium<br>- | 112<br>Cn<br>copernicium<br>- |                             | 114<br>Fl<br>flerovium<br>- |                            | 116<br>Lv<br>livermorium<br>- |                           |                        |

lanthanoids

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

actinoids

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).