

Name: ..... (       )

Class: Sec 4A

# Queenstown Secondary School



**Preliminary Examination 2022  
Secondary Four Express  
Chemistry  
6092/01**

**31 August 2022  
Wednesday**

**Time: 1200 – 1300h  
Duration: 1 hour**

**Additional Materials:** Multiple Choice Answer Sheet

## **READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.  
Do not use staples, paper clips, glue or correction fluid.  
Write your name, class and index number on the Answer Sheet in the spaces 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.

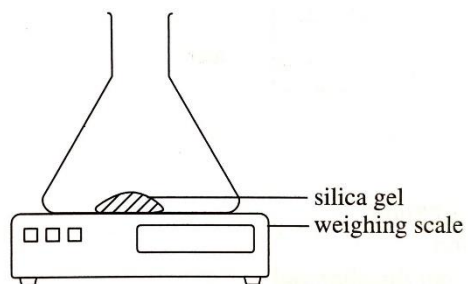
**Read the instructions on the Answer Sheet very carefully.**

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 17.  
The use of an approved scientific calculator is expected, where appropriate.

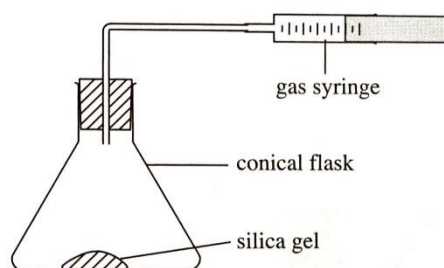
- 1 Silica gel is a solid which can absorb water vapour from the air. It can be used to limit the growth of mould on leather goods and electronic equipment.

Which of the following methods can be used to study the rate of absorption of water vapour in silica gel?

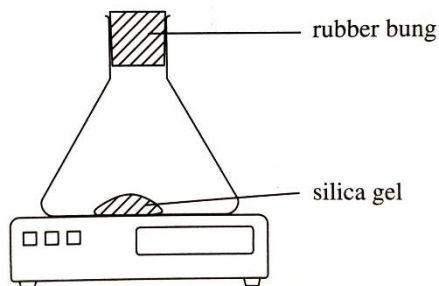
A



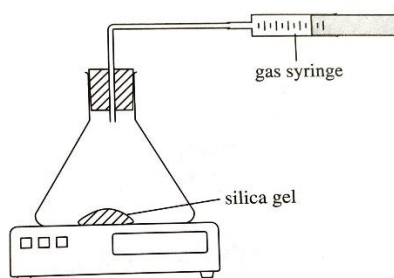
C



B



D



- 2 A liquid mixture contains methylbenzene and dilute aqueous copper(II) sulfate with different densities. Methylbenzene has a boiling point of  $111^{\circ}\text{C}$  and is insoluble in water.

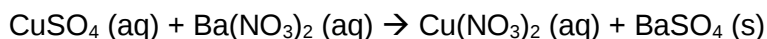
Which of the following steps can be used to obtain a liquid sample of methylbenzene and solid sample of copper(II) sulfate?

|   | step 1                  | step 2          |
|---|-------------------------|-----------------|
| A | fractional distillation | crystallisation |
| B | simple distillation     | evaporation     |
| C | use a separating funnel | crystallisation |
| D | use a separating funnel | evaporation     |

- 3 During the test for chloride ion using aqueous silver nitrate, the solution must be acidified with dilute nitric acid.

What is the purpose of adding dilute nitric acid?

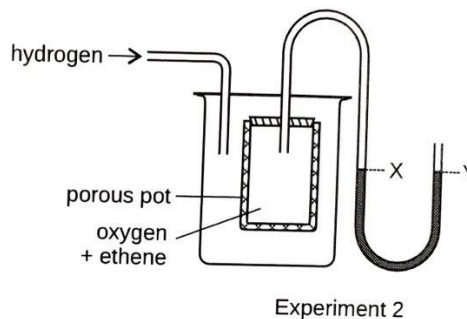
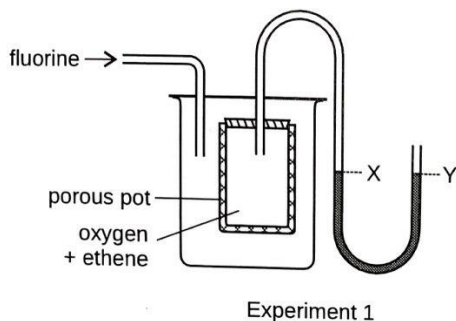
- A To oxidise the chloride ion.
  - B To increase the speed of reaction.
  - C To prevent the precipitation of other ions.
  - D To prevent the decomposition of silver chloride formed.
- 4 In an experiment,  $4.0 \text{ cm}^3$  of  $1.0 \text{ mol/dm}^3$  aqueous copper(II) sulfate and  $8.0 \text{ cm}^3$  of  $1.0 \text{ mol/dm}^3$  aqueous barium nitrate are mixed.



What does the reaction vessel contain once the reaction is complete?

- A a colourless solution only
  - B a white precipitate and a blue solution
  - C a blue precipitate and a colourless solution
  - D a white precipitate and a colourless solution
- 5 Two experimental set ups used to demonstrate diffusion of gases are shown in the diagrams below. The gases in each porous pot are ethene,  $\text{C}_2\text{H}_4$ , and oxygen,  $\text{O}_2$ .

In the first experiment, the gas introduced into the beaker is fluorine,  $\text{F}_2$ , while in the second experiment, it is hydrogen,  $\text{H}_2$ .

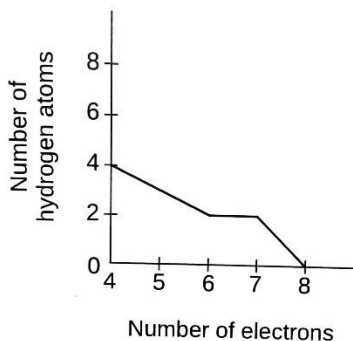


What changes, if any, to the water levels X and Y would you expect to see in both experiments?

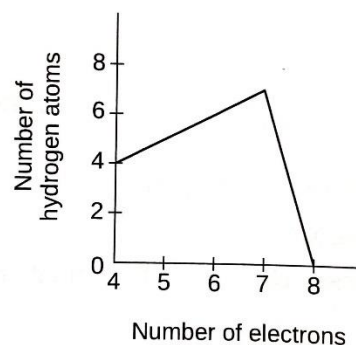
|          | experiment 1            | experiment 2            |
|----------|-------------------------|-------------------------|
| <b>A</b> | Y is higher than X      | Y is higher than X      |
| <b>B</b> | X is higher than Y      | Y is higher than X      |
| <b>C</b> | X and Y remain the same | X is higher than Y      |
| <b>D</b> | X and Y remain the same | X and Y remain the same |

- 6 Which of the following diagrams below **best** represents the relationship between the number of electrons in the valence shell of an atom and the number of hydrogen atoms which the atom is most likely to combine?

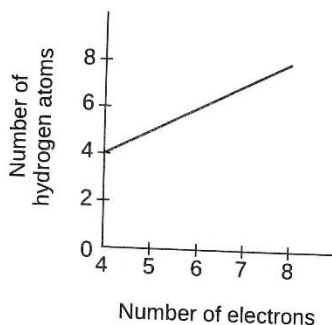
A



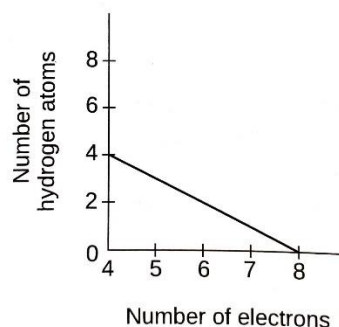
C



B



D

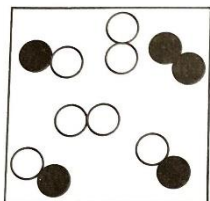


- 7 An element exists as 2 kinds of isotopes, P and Q. There are 80% of isotope P with a relative atomic mass of 45. If the relative atomic mass of the element is 47, what is the relative atomic mass of isotope Q?

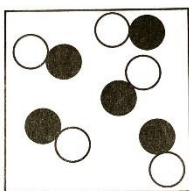
A 48                      B 52                      C 55                      D 60

- 8 Which diagram represents the reaction between hydrogen and iodine that is not yet complete?

A



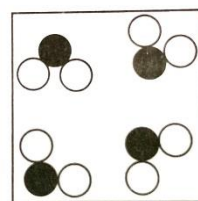
B



C



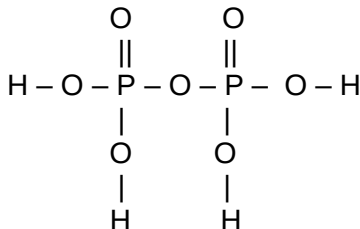
D



- 9 A compound G contains oxygen and one other element. Which property of G indicates that the bonds in G are ionic?

A It is soluble in water.  
 B It reacts with alkalis.  
 C It has a low melting and boiling point.  
 D It conducts electricity in the molten and aqueous states only.

- 10 The structural formula shows the bonding in pyrophosphoric acid.



What is the total number of bonding electrons for both phosphorus atoms in the formula?

A 10                      B 15                      C 20                      D 30

- 11 Which substance in the table below could be methanol?

| substance | melting point /°C | boiling point /°C | electrical conductivity |                  |
|-----------|-------------------|-------------------|-------------------------|------------------|
|           |                   |                   | in the liquid state     | in aqueous state |
| <b>A</b>  | -114              | -85               | nil                     | good             |
| <b>B</b>  | -98               | 65                | nil                     | nil              |
| <b>C</b>  | 180               | 218               | nil                     | nil              |
| <b>D</b>  | 420               | 970               | good                    | good             |

- 12 Solid silver metal, aqueous magnesium nitrate, solid graphite and molten sodium chloride conduct electricity.

Which two of the substances conduct electricity as they contain mobile electrons?

- A** solid silver metal and solid graphite  
**B** solid graphite and molten sodium chloride  
**C** solid silver metal and aqueous magnesium nitrate  
**D** aqueous magnesium nitrate and molten sodium chloride
- 13 40 cm<sup>3</sup> of an aqueous 0.5 mol/dm<sup>3</sup> solution of the hydroxide of metal X, exactly neutralises 80 cm<sup>3</sup> of 0.25 mol/dm<sup>3</sup> dilute sulfuric acid.

What is the formula for the sulfate of X?

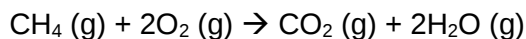
- A** XSO<sub>4</sub>                      **B** X<sub>2</sub>SO<sub>4</sub>                      **C** X(SO<sub>4</sub>)<sub>4</sub>                      **D** X<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>

- 14 A 400 g of sample of hydrated potassium sulfide crystals, K<sub>2</sub>S.xH<sub>2</sub>O, was heated to remove the water of crystallisation. The mass of solid that remained after heating was 220 g.

How many moles of water are present in 1 mole of this compound?

- A** 5                              **B** 7                              **C** 10                              **D** 12

- 15 Methane burns completely in oxygen according to the equation.

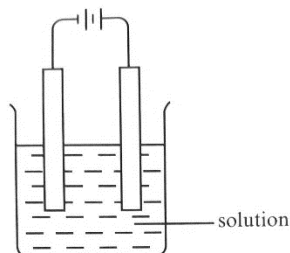


In an experiment, 40 cm<sup>3</sup> of methane and 60 cm<sup>3</sup> of oxygen are allowed to react in a closed vessel. The water vapour formed is allowed to condense. What is the volume of the resultant gaseous mixture when measured at room temperature and pressure?

- A 20 cm<sup>3</sup>                      B 40 cm<sup>3</sup>                      C 60 cm<sup>3</sup>                      D 100 cm<sup>3</sup>
- 16 On adding 50 g of impure limestone, CaCO<sub>3</sub> (*M<sub>r</sub>* = 100), to excess hydrochloric acid, 6.0 dm<sup>3</sup> of CO<sub>2</sub> was evolved at room temperature and pressure.

What is the purity of the limestone?

- A 25%                      B 50%                      C 75%                      D 100%
- 17 Four different solutions were electrolysed in separate experiments.

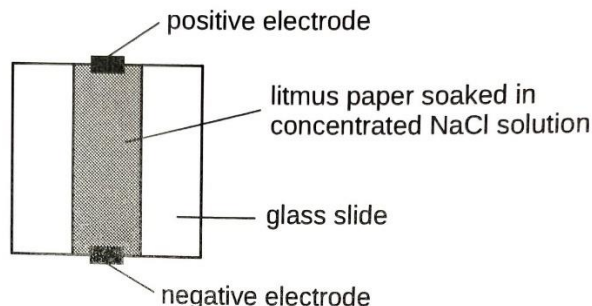


In three of the experiments, element A was formed at the cathode. In which of the following is the formation of A **not** represented by the equation shown below.



- A aqueous copper(II) sulfate with inert electrodes  
 B aqueous copper(II) sulfate with copper electrodes  
 C molten magnesium sulfate with inert electrodes  
 D concentrated aqueous magnesium bromide with inert electrodes

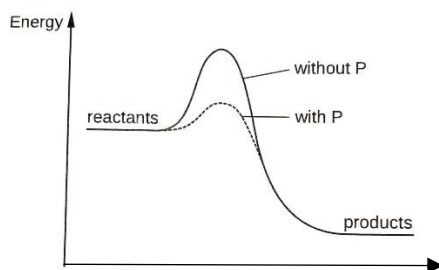
- 18** A piece of litmus paper was soaked in concentrated sodium chloride solution and supported on a glass slide and is connected to a power source as shown.



Which one of the following shows the correct observations near the positive electrode and negative electrode after the current has flowed for some time?

|          | positive electrode | negative electrode |
|----------|--------------------|--------------------|
| <b>A</b> | bleached           | blue               |
| <b>B</b> | bleached           | no change          |
| <b>C</b> | no change          | bleached           |
| <b>D</b> | no change          | red                |

- 19** A substance P is added to a reaction mixture.  
The energy profile diagram shows the effect of P on the reaction pathway.



Which of the following observations are expected to occur when P is added to the reaction mixture?

- 1 The speed of reaction increases.
- 2 The enthalpy of the reaction remains unchanged.
- 3 The reaction can take place at a lower activation energy pathway.

**A** 1 and 2

**B** 1 and 3

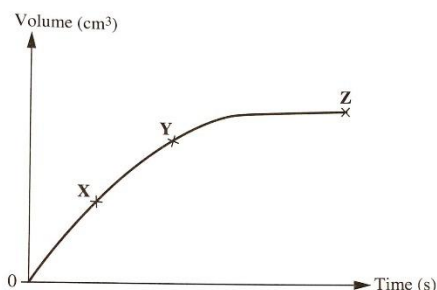
**C** 2 and 3

**D** 1, 2 and 3

20 Which statement about the hydrogen-oxygen fuel cell is **incorrect**?

- A It produces electricity, water and heat.
- B Hydrogen and oxygen are used as the main reactants.
- C The net reaction produces water and hydrogen gas only.
- D It is made up of an electrolyte between the anode and cathode.

21 The graph shows the volume of carbon dioxide given off plotted against time when a sample of calcium carbonate reacts with 100 cm<sup>3</sup> of 1 mol/dm<sup>3</sup> excess hydrochloric acid.



Which of the following statements is correct?

- A The reaction has completely stopped only at point Z.
- B The time taken for the reaction to reach completion increases when 100 cm<sup>3</sup> of 1 mol/dm<sup>3</sup> ethanoic acid is used instead.
- C More vigorous bubbling is observed at point Y than at point X.
- D The total volume of carbon dioxide evolved is greater if the sample of calcium carbonate is in powdered form.

22 Which equation does **not** represent a redox reaction?

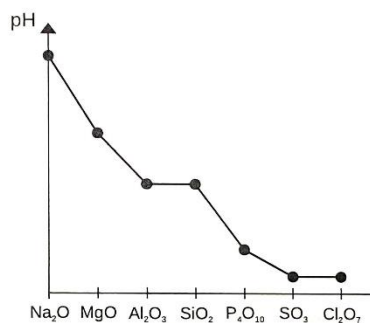
- |                                                                     |                                                                       |
|---------------------------------------------------------------------|-----------------------------------------------------------------------|
| A $\text{Cl}_2 + 2\text{I}^- \rightarrow 2\text{Cl}^- + \text{I}_2$ | C $2\text{Li} + \text{F}_2 \rightarrow 2\text{LiF}$                   |
| B $\text{Pb}^{2+} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4$     | D $\text{Cu}^{2+} + \text{Ca} \rightarrow \text{Ca}^{2+} + \text{Cu}$ |

- 23 When hydrogen peroxide is added to aqueous iron(II) chloride, the pale green solution turns brown.

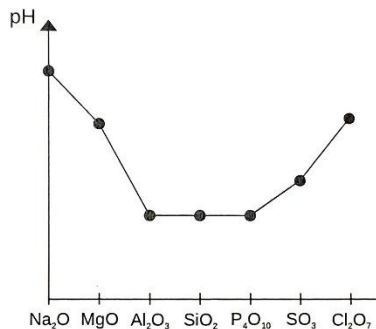
Which of the following statements **best** describes this observation?

- A Iron(II) oxide is formed.  
 B Iron(III) hydroxide is formed.  
 C Hydrogen peroxide is acting as a reducing agent.  
 D  $\text{Fe}^{2+}$  ions are oxidised to  $\text{Fe}^{3+}$  ions by hydrogen peroxide.
- 24 The pH of a dilute solution of hydrochloric acid is approximately 2.  
 When 10 g of solid sodium chloride is added to it, what will its pH be?
- A 2                      B 4                      C 7                      D 9
- 25 The oxides of the elements sodium to chlorine are added to water separately.  
 Which one of the following diagrams **best** represents the pH of the solutions produced?

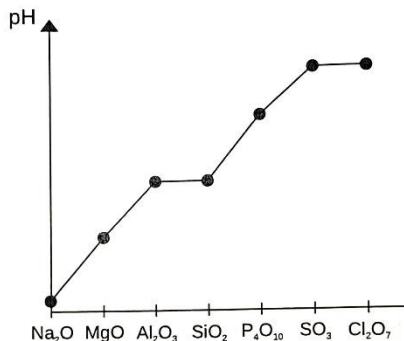
A



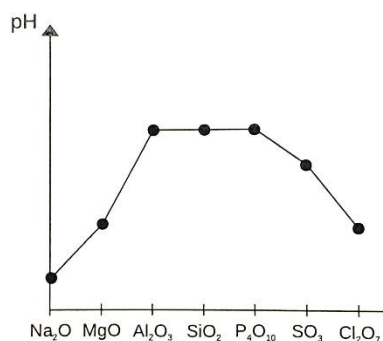
C



B



D



- A** Add dilute nitric acid, filter, evaporate filtrate to dryness.
- B** Add water, filter, evaporate filtrate to dryness and dry between filter paper.
- C** Add dilute nitric acid, filter, rinse residue and dry between filter paper.
- D** Add water, evaporate solution until saturated and perform crystallisation.

- 
- percentage of ammonia at equilibrium / %
- temperature / °C
- 400 atm
- 200 atm
- 100 atm
- 50 atm
- 25 atm

**A** Hydrogen is obtained from the air by fractional distillation.

**B** Decreasing pressure decreases the yield of the reaction.

**C** Decreasing temperature decreases the yield of the reaction.

**D** The reaction between hydrogen and nitrogen to form ammonia is irreversible.

- [illegible]

Which one of the following is a correct statement regarding W, X, Y and Z?

- A The atomic numbers increase in the order W, X, Y and Z.
- B W and X are solids, but Y and Z are gases under room conditions.
- C The valency of W and Y is one, but the valency of X and Z is two.
- D W is in Group I, X in Group V, Y in Group VI and Z in Group VII.

29 Which statement about Group I elements is true?

- A They form covalent bonds with halogens.
- B They form oxides when reacted with water.
- C Their boiling points increase on descending the group.
- D Their reactivity increases on descending the group.

30 Astatine is found in Group VII of the Periodic Table.

Which of the following is **not** a property of astatine?

- A Astatine is a solid at room temperature.
- B Astatine reacts by gaining one electron to form astatide ion.
- C Astatine can displace iodide ions from aqueous solutions.
- D Astatine can react with Group I elements to form an ionic compound.

31 Copper(II) carbonate, magnesium carbonate and iron(II) carbonate decompose when heated. The temperature at which decomposition takes place depends upon the position of the metal in the reactivity series.

What is the correct order for this decomposition?

|   | highest temperature  | →                    | lowest temperature   |
|---|----------------------|----------------------|----------------------|
| A | magnesium carbonate  | copper(II) carbonate | iron(II) carbonate   |
| B | magnesium carbonate  | iron(II) carbonate   | copper(II) carbonate |
| C | copper(II) carbonate | iron(II) carbonate   | magnesium carbonate  |
| D | iron(II) carbonate   | magnesium carbonate  | copper(II) carbonate |

- 32** A student was investigating an unknown metal X and he made the following observations in the report.
- A clean piece of X did not displace any lead when dropped into lead(II) nitrate solution.
  - When a strip of lead is dipped into copper(II) nitrate solution, it became covered with a pink substance.
  - A clean piece of X is dipped into copper(II) nitrate solution, it became covered with a pink substance.

Which of the following shows the correct arrangement of the three metals in order of increasing reactivity concluded by the student?

- A** Pb, X, Cu      **B** X, Pb, Cu      **C** Cu, Pb, X      **D** Cu, X, Pb
- 33** Which reaction is **not** a step in the production of iron from haematite in the blast furnace?
- A** Carbon burning in air to produce carbon dioxide.  
**B** Carbon dioxide reacting with iron(III) oxide to produce iron.  
**C** Calcium oxide reacting with silicon dioxide to form slag.  
**D** Calcium carbonate decomposed to form calcium oxide and carbon dioxide.
- 34** Which of the processes does **not** increase the amount of carbon in the atmosphere in the carbon cycle?
- A** combustion      **C** photosynthesis  
**B** respiration      **D** decay of organic matter

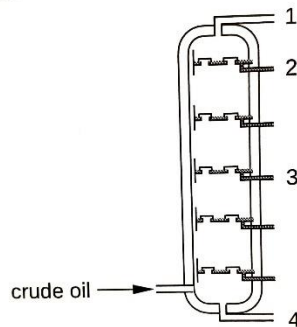
**35** The following list shows the environmental problems in our modern world.

- 1 global warming
- 2 destruction of the ozone layer
- 3 rivers and lakes turning acidic

Which of the following sets correctly matches the air pollutants to the environmental problems?

|          | 1                   | 2                   | 3                   |
|----------|---------------------|---------------------|---------------------|
| <b>A</b> | sulfur dioxide      | methane             | chlorofluorocarbons |
| <b>B</b> | methane             | sulfur dioxide      | chlorofluorocarbons |
| <b>C</b> | methane             | chlorofluorocarbons | sulfur dioxide      |
| <b>D</b> | chlorofluorocarbons | sulfur dioxide      | methane             |

**36** The diagram shows the fractional distillation of crude oil.



Which statement about the fractions is correct?

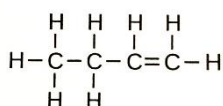
- A** Fraction 1 has the lowest flammability.
- B** Fraction 2 has the highest viscosity.
- C** Fraction 3 can undergo catalytic cracking to form fraction 2.
- D** Fraction 4 is used as a fuel in heavy vehicles such as trucks and lorries.

37 An alkane has formula  $C_{10}H_{22}$ .

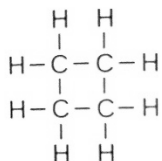
Which of the following is **not** true about the cracking of this alkane?

- A The product of cracking can be all smaller alkanes only.
- B A catalyst and high temperature are needed for cracking to occur.
- C Hydrogen produced from cracking is one of the raw materials for the Haber process.
- D Cracking produces smaller molecules to meet the supply and demand for smaller hydrocarbons.

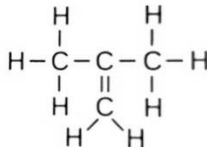
38 Which of the following are isomers of butene,  $C_4H_8$ ?



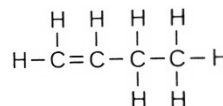
1



2



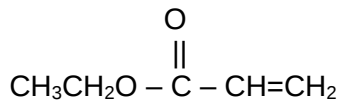
3



4

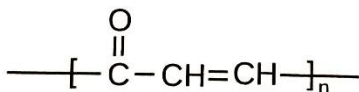
- A 1 and 3 only      B 1 and 4 only      C 1, 3 and 4      D 2, 3 and 4

- 39 The molecular structure shows an 'acrylic ester' which can be used to make the sticky substance of adhesive tape called poly(acrylate).

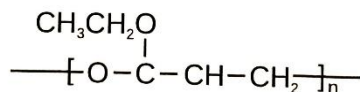


Which of the following represents the formula of poly(acrylate) which can be made from this monomer?

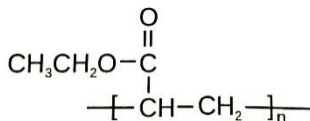
A



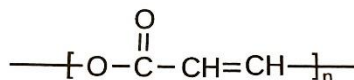
C



B



D



- 40 An organic compound X has the empirical formula  $\text{CH}_2\text{O}$  and a relative molecular mass of 60. It reacts with ethanol in the presence of concentrated sulfuric acid to give a sweet-smelling liquid.

What is the chemical formula of X?

- A  $\text{C}_2\text{H}_5\text{COCH}_2\text{OH}$     B  $\text{C}_2\text{H}_5\text{COOCH}_3$     C  $\text{C}_2\text{H}_5\text{OH}$     D  $\text{CH}_3\text{COOH}$

# The Periodic Table of Elements

| Group                                                                                 |                             |                                                                                                                                                                                                                                                                                                                                                                |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                           |                           |
|---------------------------------------------------------------------------------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|---------------------------|---------------------------|
| I                                                                                     | II                          |                                                                                                                                                                                                                                                                                                                                                                |                                 |                             |                              |                             |                              |                              |                                |                               |                               | III                         | IV                          | V                           | VI                            | VII                       | 0                         |
| <div>1<br/>H<br/>hydrogen<br/>1</div>                                                 |                             |                                                                                                                                                                                                                                                                                                                                                                |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                           |                           |
| <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 |                                                                                                                                                                                                                                                                                                                                                                |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                           |                           |
| 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<br><a href="#">La</a><br><a href="#">Ce</a><br><a href="#">Pr</a><br><a href="#">Nd</a><br><a href="#">Pm</a><br><a href="#">Sm</a><br><a href="#">Eu</a><br><a href="#">Gd</a><br><a href="#">Tb</a><br><a href="#">Dy</a><br><a href="#">Ho</a><br><a href="#">Er</a><br><a href="#">Tm</a><br><a href="#">Yb</a>                     | 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<br><a href="#">Ac</a><br><a href="#">Th</a><br><a href="#">Pa</a><br><a href="#">U</a><br><a href="#">Np</a><br><a href="#">Pu</a><br><a href="#">Am</a><br><a href="#">Cm</a><br><a href="#">Bk</a><br><a href="#">Cf</a><br><a href="#">Es</a><br><a href="#">Fm</a><br><a href="#">Md</a><br><a href="#">No</a><br><a href="#">Lr</a> | 104<br>Rf<br>rutherfordium<br>- | 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 |
|------------------------------|---------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|----------------------------|---------------------------|----------------------------|------------------------------|-----------------------------|

**actinoids**

|                           |                            |                                 |                           |                            |                            |                            |                         |                            |                              |                              |                           |                               |                            |                              |
|---------------------------|----------------------------|---------------------------------|---------------------------|----------------------------|----------------------------|----------------------------|-------------------------|----------------------------|------------------------------|------------------------------|---------------------------|-------------------------------|----------------------------|------------------------------|
| 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>— |
|---------------------------|----------------------------|---------------------------------|---------------------------|----------------------------|----------------------------|----------------------------|-------------------------|----------------------------|------------------------------|------------------------------|---------------------------|-------------------------------|----------------------------|------------------------------|

The volume of one mole of any gas is  $24 \text{ dm}^3$  at room temperature and pressure (r.t.p.)