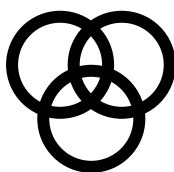


Name: _____

Register Number: _____

Class: _____



南橋中學

NAN CHIAU HIGH SCHOOL

**PRELIMINARY EXAMINATION 2020
SECONDARY FOUR EXPRESS**

For Marker's Use

Parent's Signature: _____

CHEMISTRY

6092/01

Paper 1

2 September 2020, Wednesday

Additional Material – OTAS

1 hour

INSTRUCTIONS TO CANDIDATES

Write your name, register number and class on the OTAS in the spaces provided and also in this question booklet.

There are **forty** questions in 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 OTAS.

Read very carefully the instructions on the OTAS.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done on the question paper.

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

A copy of the Periodic Table is printed on page 20.

This paper consists of **20** printed pages including the cover page.

- 1 The table shows the melting and boiling points of four pure substances. Which substance is a liquid at room temperature and would rapidly evaporate off if left in the open air?

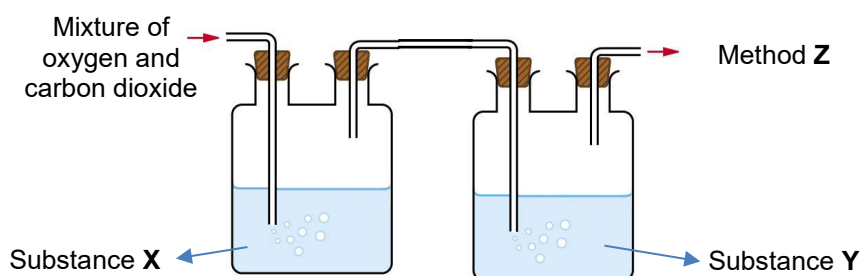
	melting point / °C	boiling point / °C
A	-15	45
B	20	120
C	-125	-8
D	120	350

- 2 The results for a titration experiment are shown below.

Initial reading / cm ³	0.00	20.40	0.50	0.70
Final reading / cm ³	20.40	41.30	20.40	20.50

What is the average volume of solution obtained from this titration?

- A** 20.40 cm³
B 20.45 cm³
C 19.85 cm³
D 19.50 cm³
- 3 In a chemical reaction, a mixture of oxygen and a small amount of carbon dioxide was produced. To obtain a **dry** sample of oxygen from the gaseous mixture, a student bubbled the mixture through substance **X**, followed by substance **Y** and then collected the **dry** oxygen using method **Z**.

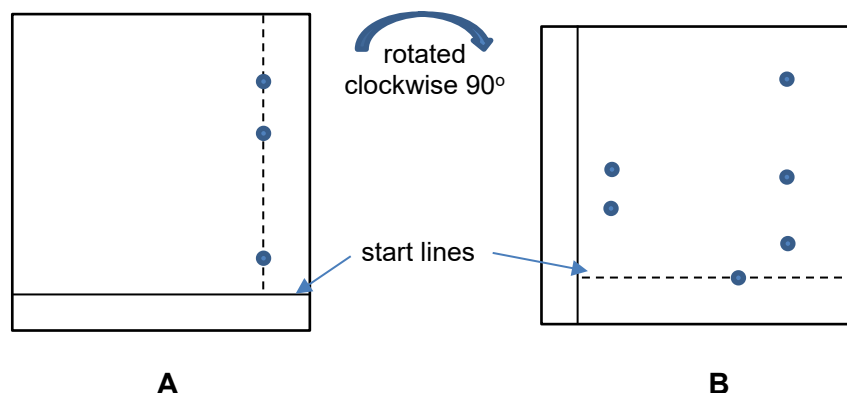


Which of the following shows the correct substances and method used?

	Substance X	Substance Y	Method Z
A	limewater	concentrated sulfuric acid	upward delivery
B	water	aqueous sodium hydroxide	downward delivery
C	aqueous sodium hydroxide	concentrated sulfuric acid	gas syringe
D	concentrated sulfuric acid	aqueous sodium hydroxide	upward delivery

- 4 A chromatography experiment was done on a brand of candy to determine the number of artificial sweeteners present.

Chromatogram **A** shows the separation of sweeteners using water as a solvent. It is then rotated clockwise 90° and placed in ethanoic acid as a solvent, as shown in chromatogram **B**.



How many different types of sweeteners are present in the candy?

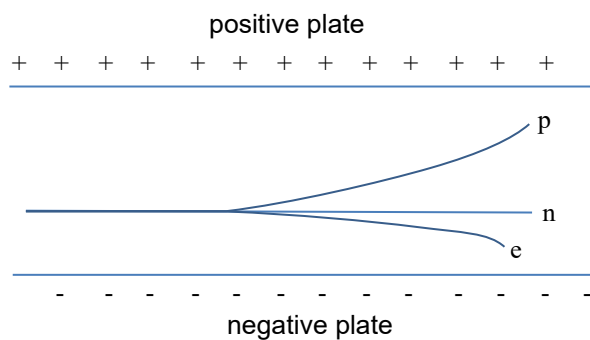
- A** 3
B 6
C 9
D 12
- 5 An impure sample of a certain liquid boils at 63°C . Which of the following compounds can the pure liquid be?

	Pure liquid	Boiling point/ $^\circ\text{C}$
A	Benzene	80
B	Hexane	69
C	Hexene	64
D	Chloroform	61

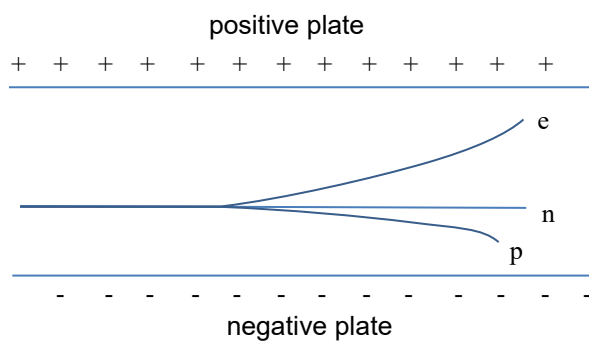
- 6 Element **X** has a proton number of 12. Element **Y** has a proton number of 9. Which one of the following properties will a compound formed between **X** and **Y** have?
- A** It has a high melting point.
B It is able to conduct electricity in all states.
C It is a gas at room temperature.
D It is insoluble in water.

- 7 A proton, neutron and electron are passed through a positively charged and a negatively charged plates.
Which of the following shows the correct path taken by the 3 sub-atomic particles?

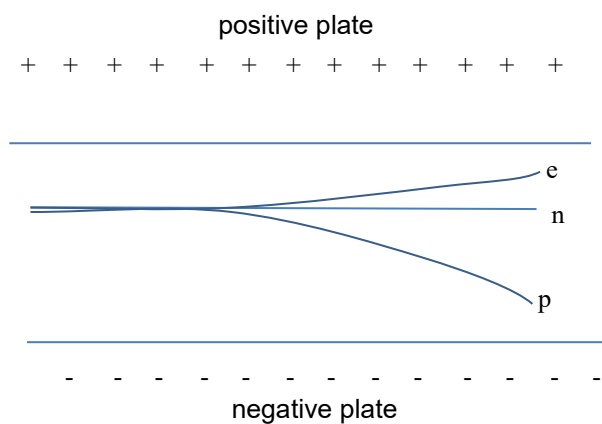
A



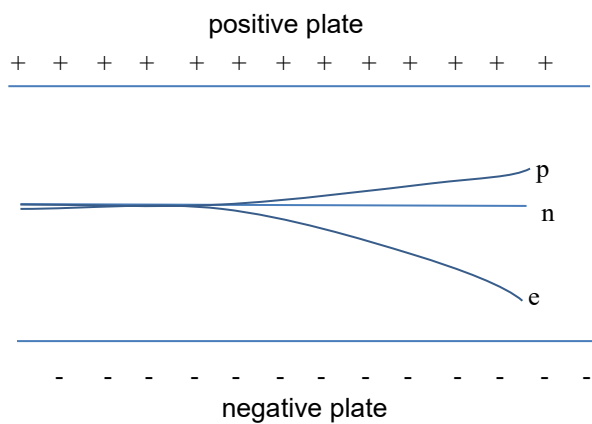
B



C



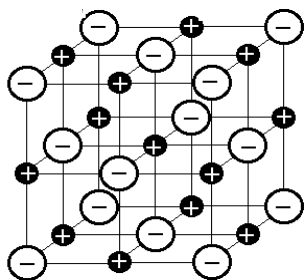
D



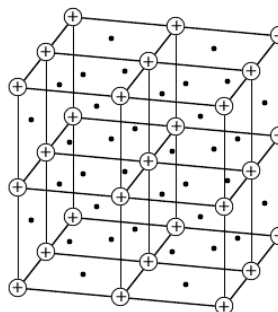
- 8 An unknown substance **X** is found to have low melting point and can conduct electricity in both solid and liquid states.

Which diagram could represent the structure of substance **X**?

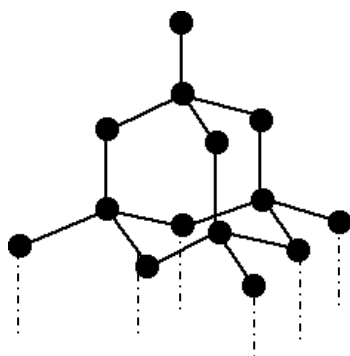
A



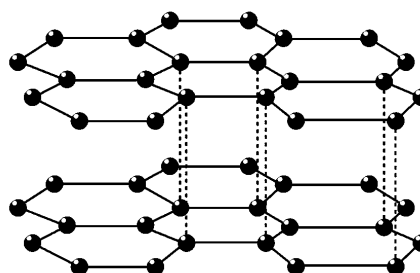
B



C



D

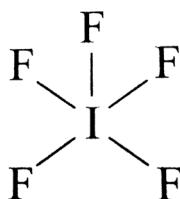


- 9 An element **P** has proton number n and forms an oxide P_2O_3 . Element **Q** has proton number $(n-2)$, what is likely the type of compound and formula of the oxide of **Q**?

- A Ionic compound, QO
- B Ionic compound, Q_2O
- C Covalent compound, QO_2
- D Covalent compound, Q_3O_2

- 10 Iodine pentafluoride was discovered by Henri Moisson in 1891 when he burnt solid iodine in fluorine gas. Iodine is found in Group VII of the periodic table.

How many bonded and unbonded electrons are found in the **outer** shell of the iodine atom in iodine pentafluoride?



- A 7
- B 8
- C 10
- D 12

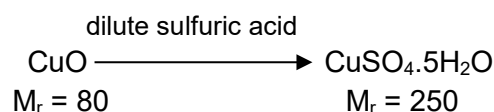
- 11 If the formula of calcium silicate is CaSiO_3 and the formula of cadmium oxide is CdO , what is the formula of cadmium silicate?

A $\text{Cd}(\text{SiO}_3)_2$
 B Cd_2SiO_3
 C $\text{Cd}_2(\text{SiO}_3)_2$
 D CdSiO_3

- 12 Which one of the following aqueous solutions contains the greatest number of ions?

A 1 dm^3 of $0.1 \text{ mol/dm}^3 \text{ Al}(\text{NO}_3)_3$
 B 1 dm^3 of $0.2 \text{ mol/dm}^3 \text{ H}_2\text{SO}_4$
 C 1 dm^3 of $0.3 \text{ mol/dm}^3 \text{ MgCl}_2$
 D 1 dm^3 of $0.4 \text{ mol/dm}^3 \text{ HCl}$

- 13 Four students prepared hydrated copper(II) sulfate by adding an excess of dilute sulfuric acid to copper(II) oxide. Each student used a different mass of copper(II) oxide.

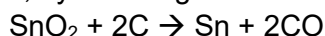


After the copper(II) sulfate had crystallised, the students dried and weighed the crystals. It is known that 1 mole of copper(II) oxide produces 1 mole of hydrated copper(II) sulfate from the reaction.

Which student produced the highest percentage yield of hydrated copper(II) sulfate?

	mass of copper(II) oxide used / g	mass of crystal produced / g
A	4.0	11.5
B	8.0	23.5
C	12.0	35.0
D	16.0	46.5

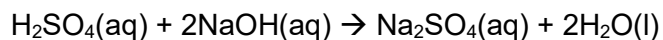
- 14 Tin is extracted from its ore, SnO_2 , by reducing it with coal in a blast furnace.



What is the percentage purity of the tin ore if 1200 g of SnO_2 produces 164 g of tin?

A $\frac{119}{164} \times \frac{1200}{151} \times 100\%$
 B $\frac{119}{164} \times \frac{151}{1200} \times 100\%$
 C $\frac{164}{119} \times \frac{1200}{151} \times 100\%$
 D $\frac{164}{119} \times \frac{151}{1200} \times 100\%$

- 15 A student carried out a titration on 25 cm³ of 0.1 mol/dm³ of sulfuric acid with 0.25 mol/dm³ of sodium hydroxide using methyl orange indicator.



He recorded the volume of sodium hydroxide to be 24.00 cm³.

Which of the following statements is/are correct?

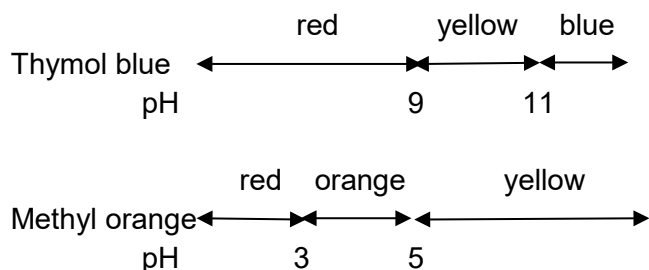
- I The colour of solution at the end of his titration is yellow.
- II The colour of solution at the end of his titration is orange.
- III He has exceeded the end-point of the titration.
- IV He has not reached the end-point of the titration.

- A II only
- B I and III
- C II and III
- D I and IV

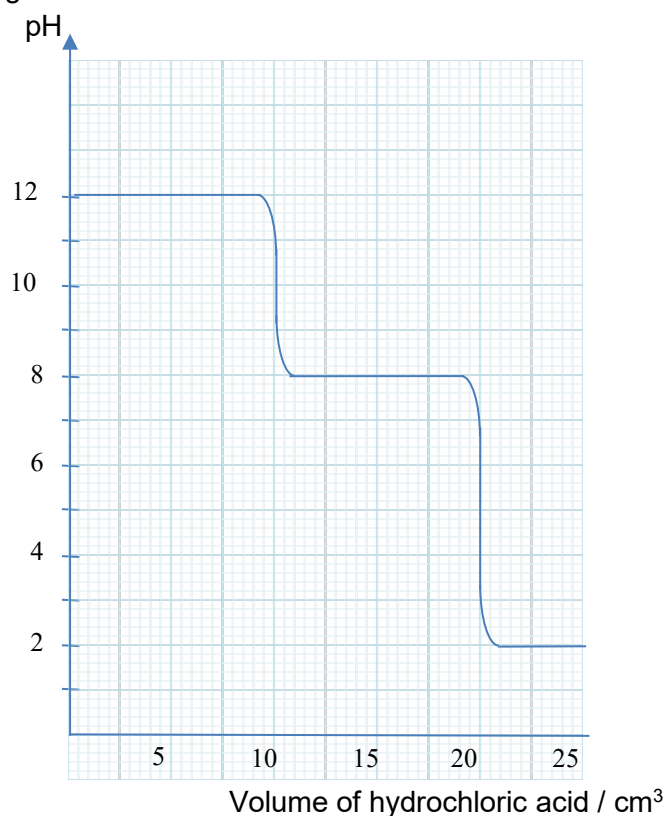
- 16 Which of the following equations show that the underlined oxide exhibits amphoteric properties?

- A K₂O + 2HCl → 2KCl + H₂O
- B Ga₂O₃ + 2KOH → 2KGaO₂ + H₂O
- C SrO + 2NH₄Cl → SrCl₂ + H₂O + 2NH₃
- D At₂O + 2LiOH → 2LiAtO + H₂O

- 17 The table below provides information about the colours of two indicators at various pH.



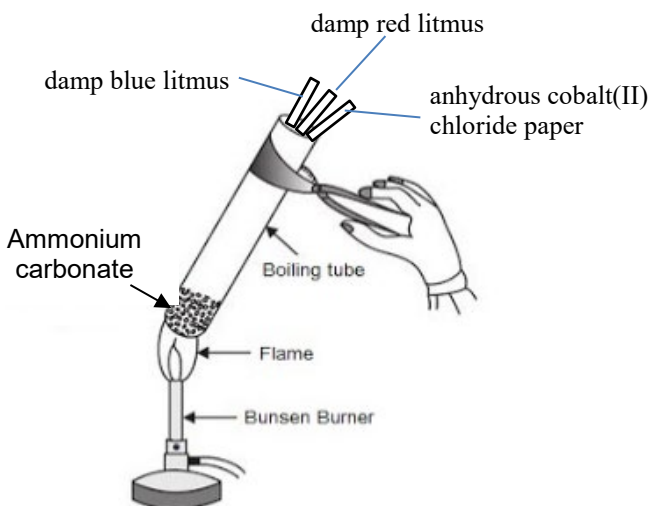
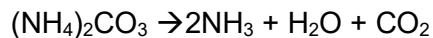
The graph shows the pH changes when sodium carbonate was titrated with dilute hydrochloric acid, using one of the indicators above.



Which of the following statements about the titration is true?

- A** Colour of thymol blue when 10 cm³ of hydrochloric acid is the same as colour of methyl orange when 20 cm³ of hydrochloric acid is added.
- B** When 15 cm³ of hydrochloric acid is added, both indicators turn yellow.
- C** When methyl orange is used as the indicator, the volume of hydrochloric acid required to reach the end-point is 15 cm³.
- D** When thymol blue is used as the indicator, the volume of hydrochloric acid required to reach the end-point is 10 cm³.

- 18 Ammonium carbonate decomposes on heating as shown in the reaction below. The gases produced were tested.



The following observations were made:

I: Damp blue litmus turned red.

II: Damp red litmus turned blue.

III: Anhydrous cobalt(II) chloride paper turned pink.

Which of the following is the correct order for the observations?

- A II → III → I
- B I → III → II
- C III → II → I
- D I → II → III

- 19 When a mixture of white solids is mixed with an excess of dilute hydrochloric acid, a colourless gas is evolved and some, but not all of the mixture dissolves.

What could the mixture contain?

- A silver chloride and calcium oxide
- B lead(II) sulfate and calcium carbonate
- C calcium oxide and sodium carbonate
- D calcium carbonate and zinc sulfate

20 In which of the following does carbon have the **same** oxidation states?

Chemical name	Sodium carbide	Iron(II) carbide	Carbon dioxide	Carbonate ion
Chemical formula	Na_2C_2	Fe_2C	CO_2	CO_3^{2-}

- A** sodium carbide and iron(II) carbide
- B** carbon dioxide and sodium carbide
- C** carbon dioxide and carbonate ion
- D** carbonate ion and iron(II) carbide

21 An unknown gas from Group VII of the Periodic table was bubbled through aqueous potassium iodide. It was observed that the solution turned from colourless to brown.

Another test was conducted with iron(II) sulfate solution. Which of the following is correct?

	Test with iron(II) sulfate	Property of unknown gas
A	pale green solution turned yellow	reducing agent
B	solution remains pale green	reducing agent
C	solution remains pale green	oxidising agent
D	pale green solution turned yellow	oxidising agent

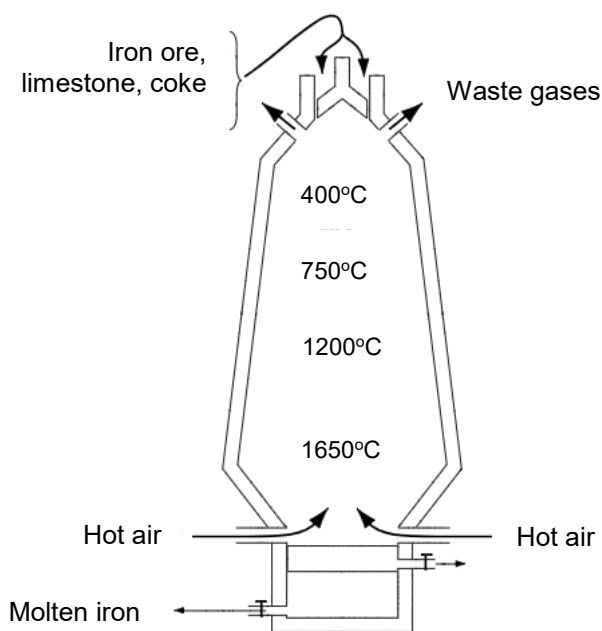
22 A student conducted a series of experiments on an unknown metal **X**. He then wrote some statements about the experiments below.

- Carbonate of **X** is decomposed by strong heating to produce an oxide with formula **XO** and carbon dioxide gas.
- Metal **X** reacts vigorously with hot steam and a bright white glow is seen.
- A pink solid was formed and blue solution turned colourless when metal **X** was added to copper(II) sulfate.
- When aqueous ammonia was added drop by drop to a solution of **X**, white precipitate was formed and remained insoluble in excess.

Which of the metals below could **X** be?

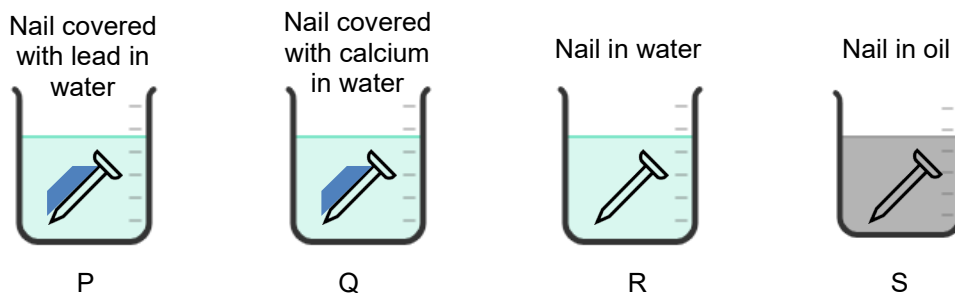
- A** copper
- B** zinc
- C** magnesium
- D** potassium

- 23 The diagram shows a blast furnace used to extract iron from haematite.



Which statement **incorrectly** explains why the bottom of the furnace is kept at very high temperatures?

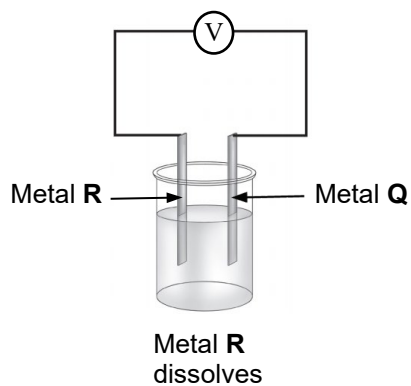
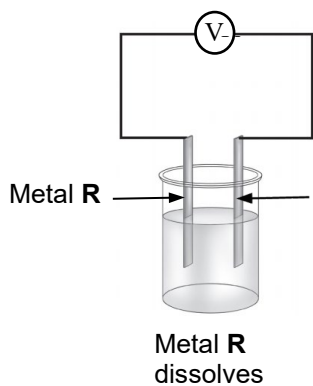
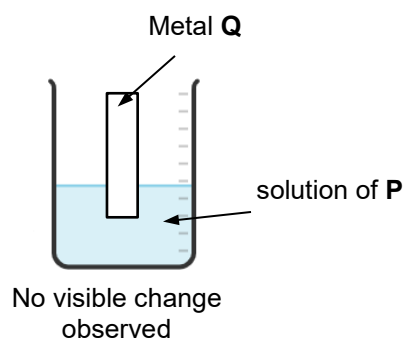
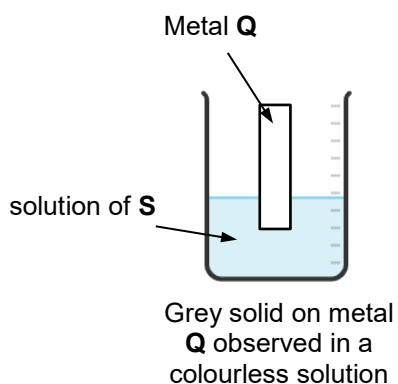
- A Combustion of coke is exothermic and occurs when hot air enters at the bottom of the furnace.
 - B Reduction of iron ore to iron is exothermic and occurs when the iron ore is fed at the top of the furnace.
 - C Iron needs to be kept molten so that it can be tapped off easily.
 - D Decomposition of limestone is endothermic and occurs when it is fed in at the top of the furnace.
- 24 The following experiments were set up to investigate the factors that affected the rate of corrosion of a steel nail.



Which of the following correctly shows the rate in which the steel nail corroded?

- | | slowest | | → | | fastest |
|---|---------|---|---|---|---------|
| A | S | Q | | R | P |
| B | S | P | | R | Q |
| C | S | Q | | P | R |
| D | R | P | | S | Q |

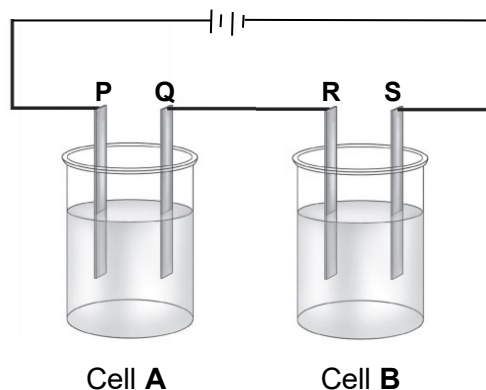
- 25 Study the 4 set-ups below to determine the order of reactivity of four metals, **P**, **Q**, **R** and **S**.



If a simple cell was set up between two of the metals above, which pair of electrodes will give the largest voltmeter reading?

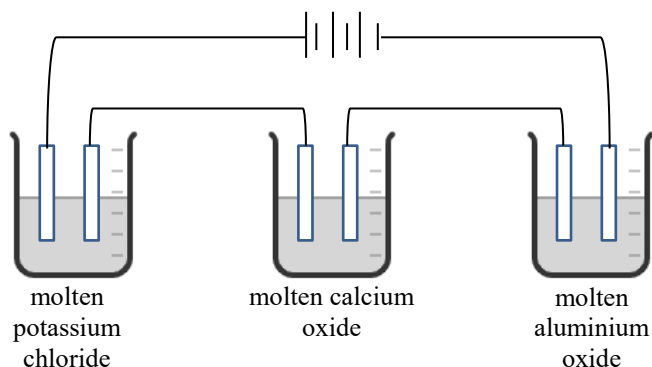
- A** metal **R** and metal **Q**
- B** metal **R** and metal **S**
- C** metal **R** and metal **P**
- D** metal **P** and metal **Q**

- 26** In the diagram below, each cell contains an aqueous salt solution as electrolyte and platinum electrodes. After some time, mass of electrode **Q** increases greater than mass of electrode **S**. No effervescence was seen from the start of the electrolysis at **Q** and **S**.



Which of the following statements must be correct?

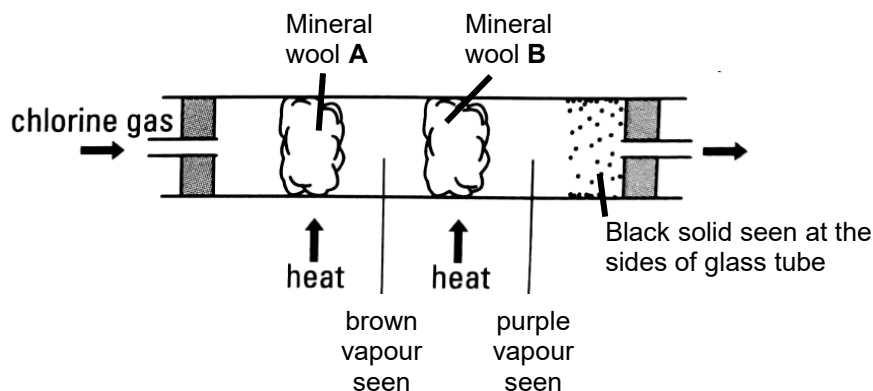
- A** The anions of the solutions in Cells **A** and **B** are different.
 - B** The cations of the solutions in Cells **A** and **B** are different.
 - C** The current flowing in Cell **A** is greater than the current flowing in Cell **B**.
 - D** The solution in Cell **A** is more concentrated than the solution in Cell **B**.
- 27** Three electrolytic cells are set up as shown below. Each cell uses carbon electrodes and three different electrolytes.



If 1 mole of electrons flows through the circuit, what is the mass of metal deposited at the cathode of each cell?

	Mass of K / g	Mass of Ca / g	Mass of Al / g
A	19.5	10	9
B	39	20	9
C	39	10	27
D	19.5	20	27

- 28 In the experiment below, chlorine gas was passed through mineral wool **A** followed by mineral wool **B**, which were soaked in potassium halide solutions.



Which of the following correctly identifies the solutions mineral wool **A** and mineral wool **B** were soaked in?

	Mineral wool A	Mineral Wool B
A	potassium bromide	potassium iodide
B	potassium iodide	potassium bromide
C	potassium bromide	potassium chloride
D	potassium iodide	potassium chloride

- 29 **X**, **Y** and **Z** are elements in period 2 of the Periodic Table.
 The oxide of **X** is soluble in water to give a solution with a pH less than 7.
 The oxide of **Y** is soluble in water to give a solution with a pH greater than 7.
 The oxide of **Z** can react with both hydrochloric acid and sodium hydroxide to give a solution of pH 7.

Arrange the three elements in **decreasing** proton number.

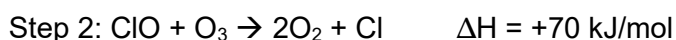
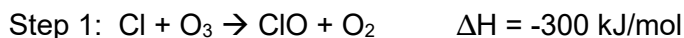
- A** **Y, Z, X**
B **Y, X, Z**
C **X, Z, Y**
D **Z, Y, X**
- 30 Arsenic belong to Group V of the Periodic Table. Which of the following is an incorrect formula for an arsenic compound?

- A** NaAsO_3
B AsCl_3
C As_2H_4
D Mg_2As_3

31 Which of the following reactions is endothermic?

- A $\text{CuCO}_3 \rightarrow \text{CuO} + \text{CO}_2$
- B $\text{Fe} + 2\text{AgNO}_3 \rightarrow \text{Fe}(\text{NO}_3)_2 + 2\text{Ag}$
- C $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- D $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

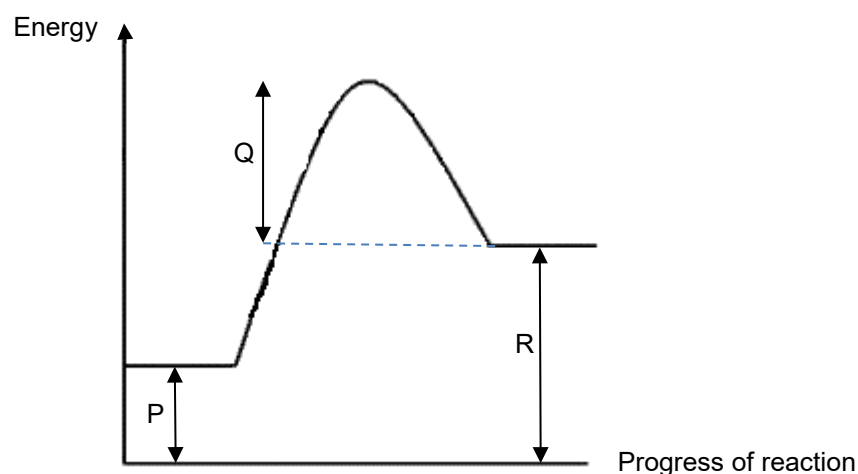
32 The depletion of the ozone layer by the reaction of chlorine atoms with CFCs occur in two steps as shown below.



Which of the following statements describing the reaction is correct?

- A The overall reaction for the depletion of ozone layer is endothermic.
- B The overall reaction is $\text{O}_3 \rightarrow \text{O}_2$.
- C Overall temperature of the surroundings increases at the end of step 2.
- D ClO acts as a catalyst in the reaction.

33 The forward reaction (endothermic) of a reversible chemical reaction is represented by the energy profile diagram below. Which of the following represents the quantities of enthalpy change and activation energy correctly for the forward and reverse reaction?



	Forward reaction (endothermic)		Reverse reaction (exothermic)	
	Enthalpy change	Activation energy	Enthalpy change	Activation energy
A	R - P	Q	R - P	Q
B	Q	Q + R	R - P	Q + R
C	R	Q + R - P	R	Q
D	R - P	Q + R - P	R-P	Q

- 34** A student conducted two experiments on a black solid. He wrote some observations from the experiments conducted.

Experiment 1: Add black solid to hydrogen peroxide.

"I see effervescence the moment I added the black solid."

Experiment 2: Add black solid to sulfuric acid.

"The black solid starts to disappear and a blue solution is formed."

In both experiments, he weighed the mass of the solid before and after each reaction.

Experiment	Before / g	After / g
1	5.0	5.0
2	5.0	3.0

Which of the following statements is correct about the black solid?

- A** The black solid is carbon.
- B** The black solid is the limiting reactant in experiment 2.
- C** The black solid is a catalyst in experiment 1.
- D** The black solid took part in both reactions.

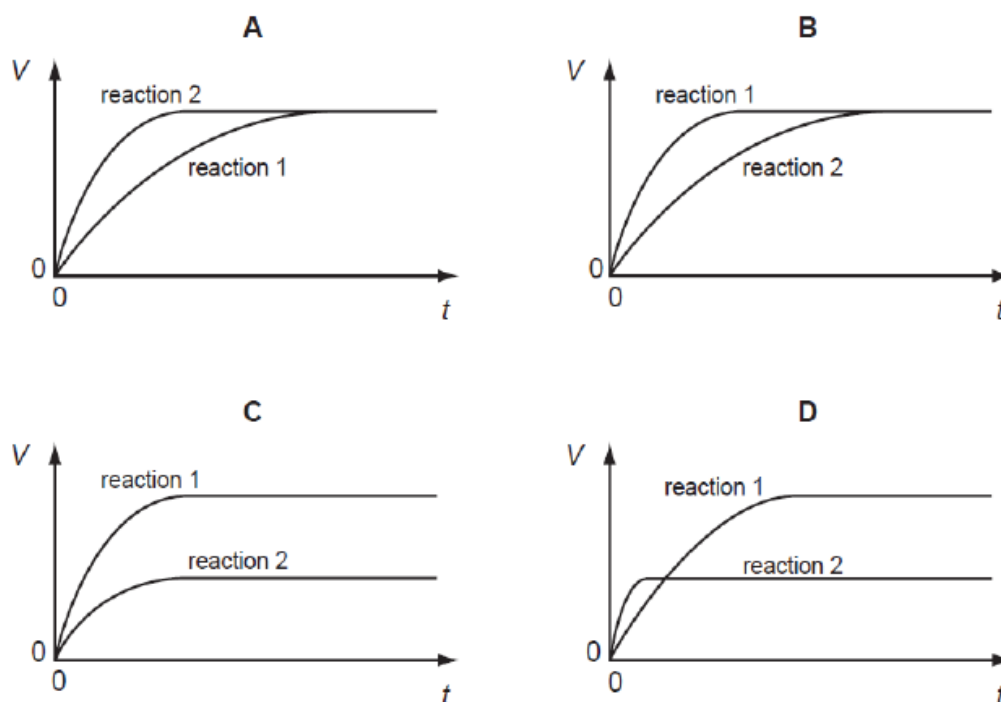
- 35** A student performs two reactions.

Reaction 1 10 g of magnesium ribbon with 1 dm³ of 2.0 mol/dm³ dilute hydrochloric acid

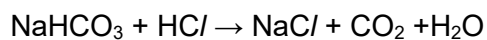
Reaction 2 5 g of magnesium powder with 1 dm³ of 3.0 mol/dm³ dilute hydrochloric acid

In both experiments, the volume of hydrogen produced, V is measured against time, t and the results are plotted graphically.

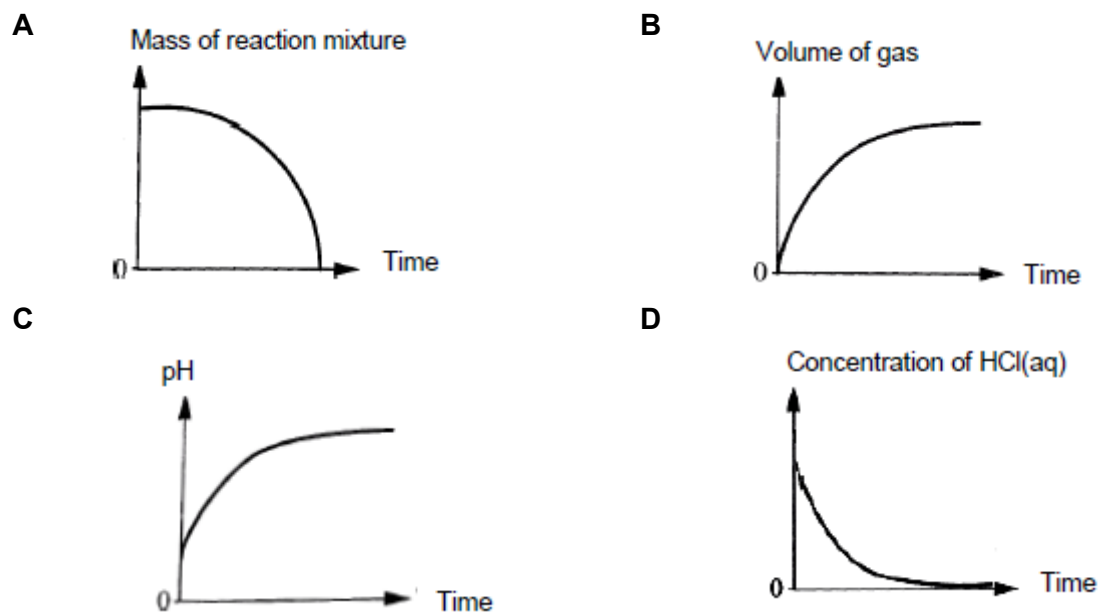
Which set of graphs is correct?



- 36 0.5 g portions of baking soda are added in excess to dilute hydrochloric acid.



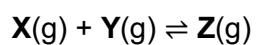
Which of the following graphs **cannot** be obtained from the above reaction?



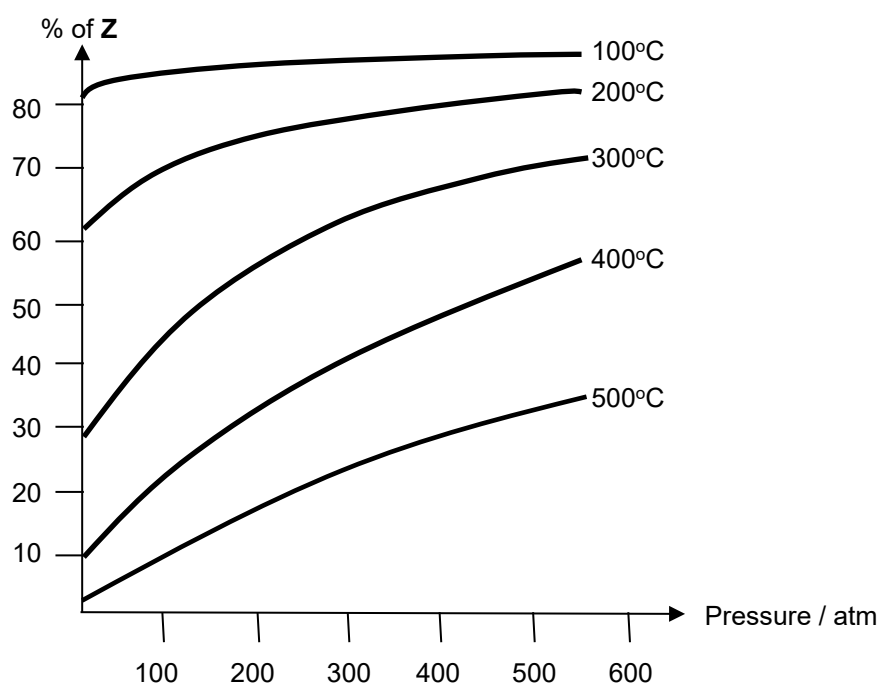
- 37 In the Haber process, ammonia is separated from hydrogen and nitrogen by

- A** absorbing ammonia with acid and treating the salt formed with a base.
- B** cooling the mixture until ammonia liquefies.
- C** dissolving ammonia in water and heating the solution.
- D** fractional distillation.

- 38 In an industrial process, two gases **X** and **Y** react together in the presence of a catalyst, to form a single gaseous product **Z**.



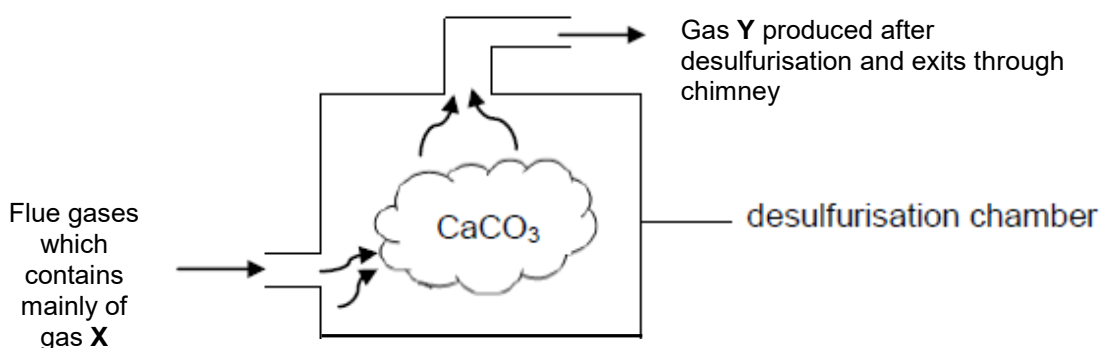
The percentage yield of product **Z** varies according to the pressure and the temperature as shown in the graphs.



Which factor decreases **both** the speed of reaction and the amount of **Z** produced?

- A removing the catalyst
- B increasing the temperature
- C decreasing the pressure
- D decreasing the temperature

- 39 The following diagram shows a desulfurisation process.



Which of the following statements about the gases **X** and **Y** is incorrect?

- A Gas **Y** will form white precipitate when bubbled through limewater.
 - B Gas **Y** is a greenhouse gas which leads to global warming.
 - C Gas **X** will turn acidified potassium manganate(VII) purple to colourless.
 - D Gas **X** is produced by internal combustion of gases in car exhaust at high temperatures.
- 40 A catalytic converter is a device used to reduce the emissions from an internal combustion engine used in most modern day vehicles. However, they may also have negative impacts on the environment.

Which of the following describes the negative impact that catalytic converters cause?

- A They contribute to the acidic gases in air.
- B They emit by-products which lead to the depletion of the ozone.
- C They increase the amount of carbon particles in the air which leads to smog.
- D They contribute the greenhouse gases which lead to global warming.

~~ End of Paper~~
~~~Do check your answers!~~~

# 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   |                                                                                                      |                                 |                             |                              |                             |                               |                              |                                |                               |                               |                               |                              |                              |                               |                           |                           | 5<br>B<br>boron<br>11       | 6<br>C<br>carbon<br>12    | 7<br>N<br>nitrogen<br>14    | 8<br>O<br>oxygen<br>16  | 9<br>F<br>fluorine<br>19     | 10<br>Ne<br>neon<br>20  |
| 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<br>52<br>137                                                                  | 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>52<br>137                                                                   | 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 dm<sup>3</sup> at room temperature and pressure (r.t.p.).