

[Pure] Chemistry O Level Exam Paper
Preliminary Examination Set [III]
Secondary Four Express



CANDIDATE NAME:

CLASS:

INDEX NUMBER:

(Updated 2024)

6092/01

Chemistry

1 hour

Paper 1 Multiple Choice

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

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** or **D**.

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

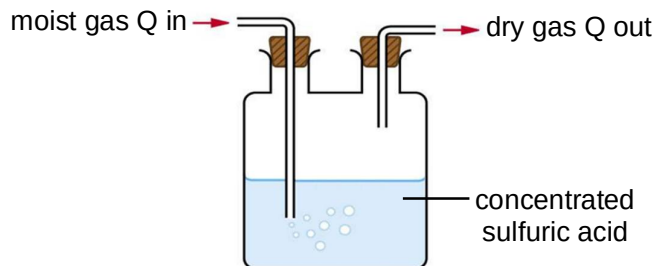
Read the instructions on the Answer Sheet very carefully.

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.

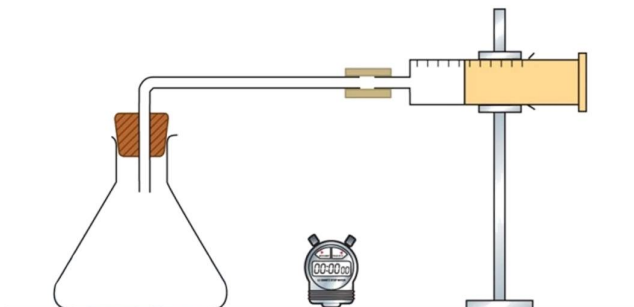
The use of an approved scientific calculator is expected, where appropriate.

- 1 The setup used to dry gas Q is shown.



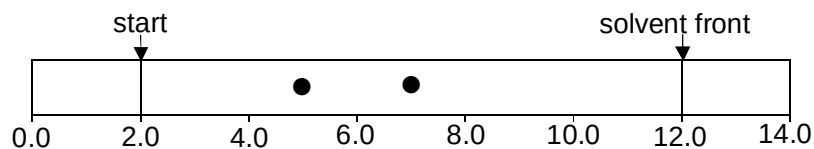
What can be deduced about gas Q?

- A Gas Q is denser than air.
 - B Gas Q is either acidic or neutral.
 - C Gas Q is insoluble in water.
 - D Gas Q is soluble in concentrated sulfuric acid.
- 2 The diagram shows a method of measuring the rate of reaction.



Which reaction is **not** suitable for using this method to measure its rate?

- A $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$
 - B $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
 - C $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
 - D $\text{NaOH} + \text{NH}_4\text{Cl} \rightarrow \text{NaCl} + \text{NH}_3 + \text{H}_2\text{O}$
- 3 A food colouring is analysed by paper chromatography.



From its chromatogram, what is the R_f value of the least soluble dye?

- A 0.25
- B 0.30
- C 0.35
- D 0.40

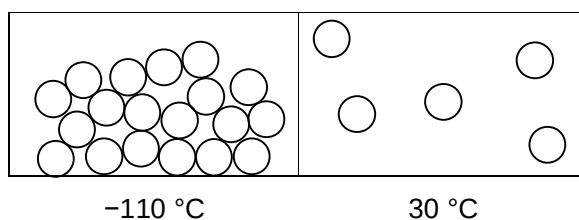
- 4 From which mixture can the first substance be obtained by adding water, stirring and filtering?
- A copper and copper(II) chloride
 - B iodine and magnesium carbonate
 - C silicon dioxide and zinc oxide
 - D sodium chloride and sodium sulfate

- 5 A chemist is given an unknown white powder.

What should the chemist do to determine the purity of the unknown substance?

- A burn it in excess oxygen
 - B conduct a solubility test in water
 - C measure its melting point
 - D pass electricity through it
- 6 An aqueous solution contains a mixture of Cl^- , CO_3^{2-} and SO_4^{2-} ions.
- Which aqueous reagent can be added to remove only CO_3^{2-} ions from the mixture?
- A $AgNO_3$
 - B $Ba(NO_3)_2$
 - C HNO_3
 - D $NaOH$

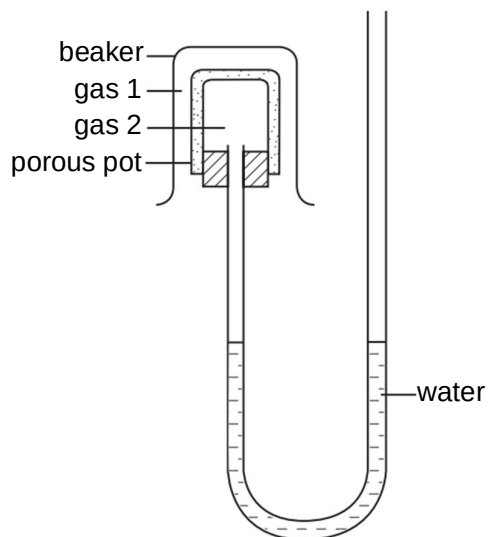
- 7 The diagrams represent the arrangement of particles in substance T at two different temperatures.



What are the melting and boiling points of substance T?

	melting point / °C	boiling point / °C
A	-157	-152
B	-112	-108
C	-101	-35
D	-7	59

- 8 A beaker containing gas 1 is inverted over a porous pot containing gas 2 as shown.



Which two gases will cause no change in the water level?

- A carbon monoxide and nitrogen
B carbon dioxide and nitrogen dioxide
C ethane and ethene
D ethane and propane
- 9 A particle, with a +4 charge, contains 48 particles in its nucleus and 18 electrons.
What are the numbers of neutrons and protons found in its nucleus?

	number of neutrons	number of protons
A	26	22
B	28	20
C	30	18
D	34	14

- 10 Which substance contains both covalent and ionic bonds?
- A hydrogen chloride
B iron(II) sulfide
C manganese dioxide
D potassium nitrate

11 Phosphorus exists in several allotropes.

White phosphorus is a soft solid with a melting point of 44 °C, while red phosphorus is a hard solid with a melting point of 590 °C.

White phosphorus consists of discrete P₄ molecules, while red phosphorus consists of a network of P₄ units that have been linked.

Which statement is true of these two forms of phosphorus?

- A** Both forms are soluble in organic solvents and water.
- B** Both forms can conduct electricity.
- C** Both forms have a simple molecular structure.
- D** Both forms have strong covalent bonds between phosphorus atoms.

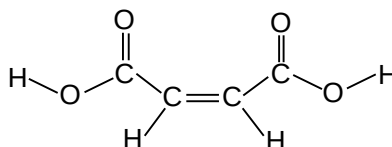
12 Metals have positive ions in a 'sea' of electrons.

Which statement(s) is/are correct?

- 1 Aluminium provides more electrons for the 'sea' than magnesium.
- 2 The 'sea' of electrons allows metals to conduct electricity only in solid state.
- 3 The 'sea' of electrons cannot be found in alloys.

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

13 A molecule of maleic acid has its structure shown.



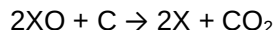
How many valence electrons are **not** shared in this molecule?

- A** 8 **B** 14 **C** 16 **D** 28

14 How many hydrogen atoms are there in 17 g of phosphine, PH₃?

- A** 3.01×10^{23} **B** 6.02×10^{23} **C** 9.03×10^{23} **D** 1.20×10^{24}

- 15 On heating with carbon, the oxide of metal X is reduced.



When 120 g of XO is heated, 18 dm³ of CO₂ is produced.

What is the relative atomic mass of X?

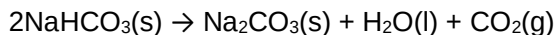
- A 56 B 59 C 64 D 65

- 16 The industrial production of ammonia is carried out via the Haber process.

Suppose unreacted gases are not recycled, what volumes of nitrogen and hydrogen are required to produce 600 dm³ of ammonia in a process that is only 15% efficient?

	volume of N ₂ / dm ³	volume of H ₂ / dm ³
A	45	135
B	255	765
C	300	900
D	2000	6000

- 17 On heating, sodium hydrogen carbonate decomposes.



When all 105 g of sodium hydrogen carbonate undergoes thermal decomposition, what is the volume of 0.50 mol/dm³ of hydrochloric acid required to exactly react with the residue formed?

- A 0.40 dm³ B 0.80 dm³ C 1.25 dm³ D 2.50 dm³

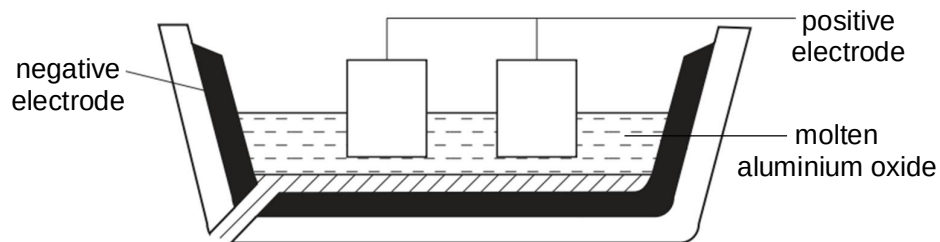
- 18 The table shows the results for the electrolytic purification of copper, using aqueous copper(II) sulfate as the electrolyte.

	initial mass / g	final mass / g
impure copper anode	110	10
pure copper cathode	10	90

What was the percentage impurity of the impure copper anode?

- A 9.1% B 27.3% C 72.7% D 90.9%

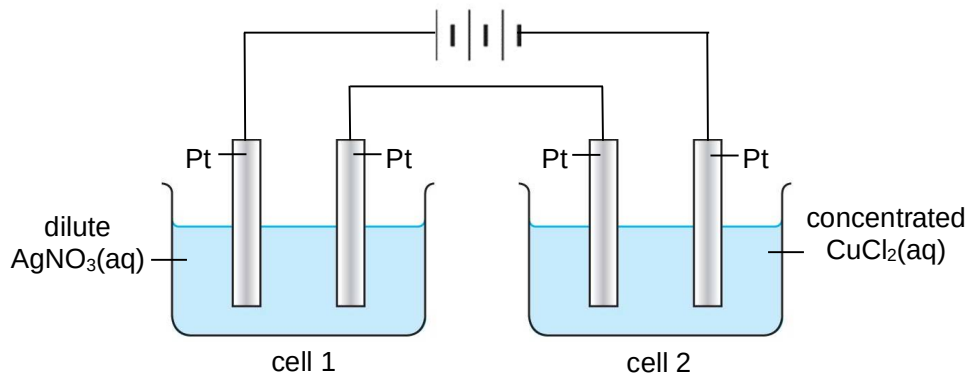
19 The diagram shows the electrolytic production of aluminium.



Which equations represent the reactions taking place at the inert electrodes?

	negative electrode	positive electrode
A	$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$	$2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$
B	$\text{Al}^{3+} \rightarrow \text{Al} + 3\text{e}^-$	$2\text{O}^{2-} + 4\text{e}^- \rightarrow \text{O}_2$
C	$2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$	$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$
D	$2\text{O}^{2-} + 4\text{e}^- \rightarrow \text{O}_2$	$\text{Al}^{3+} \rightarrow \text{Al} + 3\text{e}^-$

20 Two cells undergoing electrolysis are connected in series.



What are the substances formed at the platinum electrodes?

	cell 1		cell 2	
	anode	cathode	anode	cathode
A	nitrogen	hydrogen	chlorine	hydrogen
B	oxygen	hydrogen	oxygen	copper
C	oxygen	silver	chlorine	copper
D	oxygen	silver	oxygen	hydrogen

- 21** In combustion reactions, some substances release more energy than others.

The enthalpy change of combustion, ΔH_c , indicates the amount of energy released when one mole of a substance burns completely in oxygen.

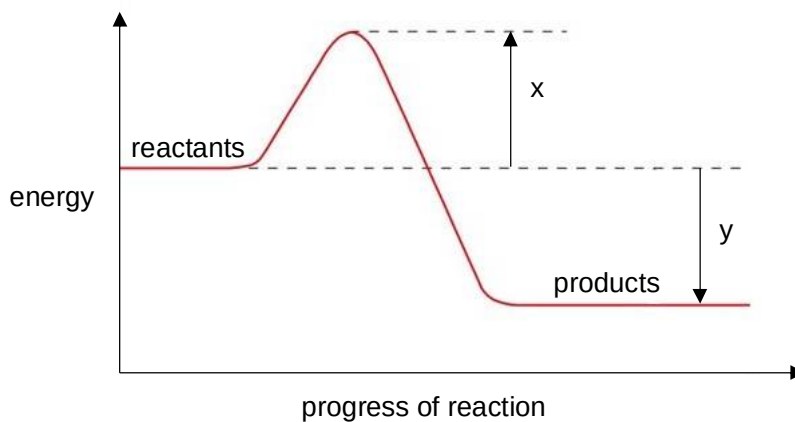
The table shows the ΔH_c of four substances.

substance	formula	state	ΔH_c in kJ/mol
ethanol	C_2H_5OH	liquid	-1367
hydrogen	H_2	gas	-286
octane	C_8H_{18}	liquid	-5470
propane	C_3H_8	gas	-2220

Which substance will release the most energy when 1 g of it is completely combusted?

- A** ethanol **B** hydrogen **C** octane **D** propane

- 22** The energy profile diagram for a reversible reaction is shown.



Which statements about the reaction are true?

- 1 The activation energy of the forward reaction is x.
- 2 The activation energy of the reverse reaction is x + y.
- 3 The enthalpy change of the forward reaction has a positive value.
- 4 The products of the reverse reaction have less energy than reactants.

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

23 What condition(s) used in the Haber process can increase both the reaction rate and yield?

- 1 operating at a high pressure
- 2 operating at a high temperature
- 3 using a finely divided catalyst

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

24 The formula of bromate ion is BrO_3^- .

Which row shows the oxidation states of each element in bromate ion?

	Br	O
A	-1	-6
B	-1	-2
C	+5	-2
D	+5	-6

25 When acidified potassium iodide solution is added to aqueous hydrogen peroxide, a colour change is observed.

Which row shows the colour change and its explanation?

	colour change	explanation
A	brown to colourless	iodide ions gain electrons and are reduced
B	brown to colourless	iodide ions lose electrons and are oxidised
C	colourless to brown	iodide ions gain electrons and are reduced
D	colourless to brown	iodide ions lose electrons and are oxidised

26 When an effervescent tablet is dissolved in water, it produces a fizzing effect due to a chemical reaction involving an acid in the tablet.

Which pair could be involved in the reaction?

- A** citric acid and sodium bicarbonate
- B** ethanoic acid and magnesium hydroxide
- C** hydrochloric acid and potassium
- D** nitric acid and silver nitrate

- 27** Fertilisers are usually salts containing nitrogen, phosphorus and potassium.

An ammonium salt is formed when ammonia reacts with an acid.

Which equation representing the formation of ammonium salt is **not** correct?

- A** $\text{NH}_3(\text{g}) + \text{CH}_3\text{COOH}(\text{aq}) \rightarrow \text{CH}_3\text{COONH}_4(\text{aq})$
B $\text{NH}_3(\text{g}) + \text{HCl}(\text{aq}) \rightarrow \text{NH}_4\text{Cl}(\text{aq})$
C $\text{NH}_3(\text{g}) + \text{HNO}_3(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{aq})$
D $\text{NH}_3(\text{g}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{NH}_4\text{SO}_4(\text{aq})$

- 28** When dissolved in water, iron(III) chloride hydrolyses to form iron(III) hydroxide and hydrochloric acid.

Due to the formation of hydrochloric acid, the resulting solution is acidic.

Which row explains the pH of a sample of iron(III) chloride in water?

	pH	explanation
A	3	concentration of H^+ is less than that of OH^-
B	3	concentration of H^+ is more than that of OH^-
C	11	concentration of H^+ is less than that of OH^-
D	11	concentration of H^+ is more than that of OH^-

- 29** How many soluble salts can be made using only barium chloride, copper(II) oxide, lead and sulfuric acid?

- A** 0 **B** 1 **C** 2 **D** 3

- 30** Three elements X, Y and Z have consecutive increasing atomic numbers.

If element X is a noble gas, what will be the formulae of the oxides of Y and Z?

- A** YO and Z_2O
B Y_2O and ZO
C Y_2O_3 and ZO_2
D YO_2 and Z_2O_3

- 31** Element J is in the same group as bromine but has a lower boiling point.

Which statement about element J is **not** correct?

- A** It can displace bromine from aqueous potassium bromide.
- B** It has a darker colour than bromine.
- C** It is a gas at room temperature.
- D** It is a more powerful oxidising agent than bromine.

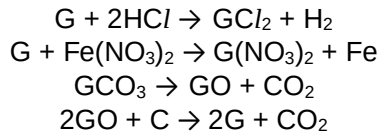
- 32** Part of the Periodic Table is shown.

[illegible]

Which statement about the elements P, Q, R and S is correct?

- A** P is monatomic.
B P loses an electron when it reacts with Q.
C Q has a lower melting point than R.
D R has a lower density than S.

- 33** The reactions of metal G and its compounds are shown.



What could be the identity of G?

- A** Cu **B** Mg **C** Pb **D** Zn

34 The table shows the reactions of manganese.

reaction with	observation
cold water	no visible change
dilute acid	effervescence
steam	effervescence

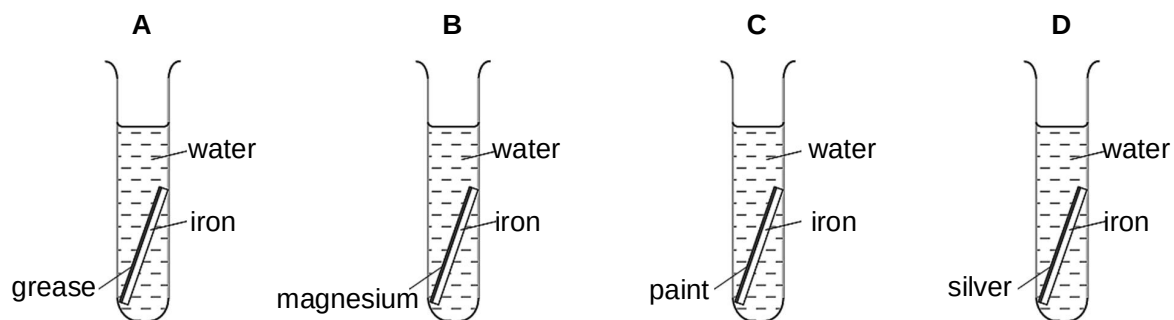
Which property of manganese can be determined from these reactions?

- A** It can be extracted by heating its oxide with carbon.
- B** It can reduce an oxide of chromium.
- C** It reacts with oxygen to form various oxides.
- D** Its oxides are used as catalysts in various reactions.

35 Four test-tubes were set up as shown.

Each piece of iron was protected on one side by a different coating.

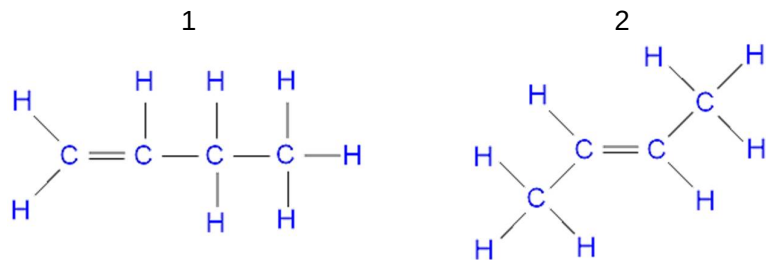
In which test-tube is the iron least likely to rust?



36 Which statement about biofuels is correct?

- A** Biofuels are carbon-neutral and do not release any carbon dioxide when burnt.
- B** Biofuels can be mixed with petrol as fuel for motor cars.
- C** Biofuels can be produced and used with no impact on the environment.
- D** Biofuels can only be produced from food crops like corn and sugarcane.

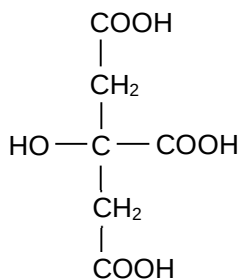
37 The figures show two isomers of butene.



Which statement about these isomers is correct?

- A They are the only two isomers of butene.
- B They burn in excess oxygen to produce soot.
- C They have slightly different boiling points.
- D They react with steam to produce butan-1-ol.

38 The structure of citric acid is shown.

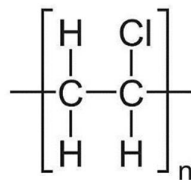


Which statements describe citric acid?

- 1 It decolourises aqueous bromine.
- 2 It reacts with aqueous sodium carbonate.
- 3 Its pH can be estimated using Universal Indicator.
- 4 Its reaction with aqueous sodium hydroxide takes in heat from the surroundings.

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

- 39** The structure of polyvinylchloride, PVC, is shown.



Which row shows the molecular formula of monomer and type of reaction to synthesize PVC?

	monomer	reaction
A	CH ₃ Cl	addition polymerisation
B	C ₂ H ₃ Cl	condensation polymerisation
C	C ₂ H ₃ Cl	addition polymerisation
D	C ₂ H ₅ Cl	condensation polymerisation

- 40** Some polymers undergo depolymerisation through acid hydrolysis.

Which row shows a polymer and its product(s) formed from hydrolysis?

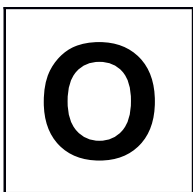
	polymer	product(s)
A	nylon	dicarboxylic acid and diol
B	poly(ethene)	alkene
C	Teflon	alkene
D	Terylene	dicarboxylic acid and diol

End of Paper

The Periodic Table of Elements

Group																		
1	2											13	14	15	16	17	18	
Key proton (atomic) numbers atomic symbol name relative atomic mass								1 H hydrogen 1										He helium 4
													5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
													13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
3 Li lithium 7	4 Be beryllium 9																	
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12							
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84	
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe 131	
55 Cs c 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium 209	85 At astatine 210	86 Rn r 222	
Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganeson –	
lanthanoids			57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 162	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lu 175	
actinoids			89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –	

The volume of any gas is 24 dm³ at room temperature and pressure (r.t.p.)
The Avogadro constant, *L* = 6.02 × 10²³ mol⁻¹.



[Pure] Chemistry O Level Exam Paper
Preliminary Examination Set [III]
Secondary Four Express



CANDIDATE NAME:

CLASS:

INDEX NUMBER:

(Updated 2024)

6092/02

Chemistry

1 hour 45 minutes

Paper 2 Theory

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid/tape.

Section A

Answer **all** questions.

Section B

Answer **all** questions. Question 11 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Section A	
Section B	
Total	

Section A
Answer **all** questions.

- 1 (a) Choose from the substances listed to answer the questions.

aluminium oxide
calcium oxide
carbon dioxide
iron(II) oxide
nitrogen monoxide
potassium oxide
sulfur dioxide

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

Identify the substance which

- (i) dissolves in water to raise the pH of soils,
..... [1]
- (ii) is a neutral oxide,
..... [1]
- (iii) reacts with both acids and alkalis,
..... [1]
- (iv) turns acidified potassium manganate(VII) from purple to colourless,
..... [1]
- (v) warms with excess hydrochloric acid to form a green solution.
..... [1]

- (b) The following are statements about alkali metals in the Periodic Table.

Put a tick (✓) in **one** box in each row to show which statements are **true** and which are **false**.

	true	false
They all float on water.		
They lose electrons more easily down the group.		
They rapidly tarnish in air.		
They react with water to form two alkaline products.		

[2]

[Total: 7]

- 2 Magnesium, with the symbol Mg and an atomic number of 12, has a relative atomic mass of approximately 24.3.

(a) Define *relative atomic mass* of an element.

.....
..... [1]

(b) The relative atomic mass of 24.3 is a weighted average of the masses of its three naturally occurring isotopes, Mg-24, Mg-25, and Mg-26.

Given that the relative abundance of Mg-25 is 10%, calculate the relative abundances of Mg-24 and Mg-26.

relative abundance of Mg-24 [1]

relative abundance of Mg-26 [1]

(c) Given that the rate of diffusion of a gas is inversely proportional to the square root of its molar mass, comment on the relative rates of diffusion for the three Mg isotopes in the gaseous state.

.....
..... [1]

- (d) Analysis of a sample of a magnesium compound shows that it contains 18.9 g of magnesium, 5.8 g of boron and 25.3 g of oxygen.

Deduce the empirical formula for this magnesium compound.
Show your working.

empirical formula [2]

- (e) Admontite is a hydrated magnesium borate mineral with formula, $\text{MgB}_6\text{O}_{10} \cdot 7\text{H}_2\text{O}$.

It has an alternative formula, $\text{MgB}_6\text{O}_x(\text{OH})_6 \cdot y\text{H}_2\text{O}$.

State the values of x and y in the alternative formula.

x = and y = [1]

[Total: 7]

3 Fig 3.1 shows the structures of three tetrafluorides.

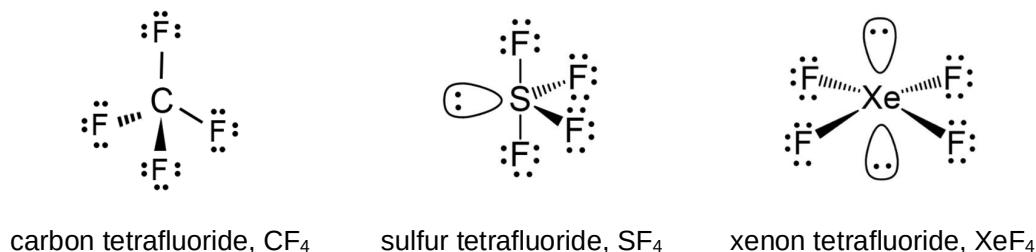


Fig 3.1

Each of these tetrafluorides exemplifies the diversity of chemical behaviour that can arise from different central atoms bonded to fluorine.

(a) Suggest how two of these structures do **not** follow normal bonding rules.

.....
.....
.....
..... [2]

(b) Hydrolysis of sulfur tetrafluoride gives an intermediate product, thionyl fluoride, SOF_2 . There is a double bond between atoms of sulfur and oxygen and a single bond between atoms of sulfur and fluorine.

Draw a 'dot-and-cross' diagram to show the bonding in a molecule of SOF_2 .

Show outer electrons only.

[2]

(c) Explain, in terms of structure and bonding, why these fluoride compounds have low melting points.

.....
.....
.....
..... [2]

[Total: 6]

- 4 The decomposition of most metal nitrates typically occurs upon heating, resulting in the formation of metal oxides, nitrogen dioxide and oxygen.

(a) The thermal decomposition of calcium nitrate is considered a redox reaction.

Use oxidation states to explain what is reduced and what is oxidised during the thermal decomposition of calcium nitrate.

.....
.....
.....
.....
..... [2]

(b) A characteristic feature of this thermal decomposition is the release of nitrogen dioxide gas.

Observation of brown fumes during heating would indicate that the metal nitrate is undergoing decomposition.

Describe a test to identify the **other** gas produced.

.....
..... [1]

(c) In an experiment, a fixed amount of three metal nitrates, calcium nitrate, lead(II) nitrate and zinc nitrate, are heated separately.

(i) Assuming that the same amount of heat is applied, which metal nitrate will take the shortest time for nitrogen dioxide to appear? Explain your answer.

.....
.....
.....
.....
..... [2]

(ii) Which solid residue is yellow when hot and turns white on cooling?

..... [1]

[Total: 6]

5 Potassium nitrate is a useful water-soluble fertiliser.

(a) Name the method to prepare potassium nitrate.

..... [1]

(b) Write an equation, with state symbols, for the reaction to prepare potassium nitrate.

..... [2]

(c) Describe how pure dry crystals of potassium nitrate are obtained from its aqueous solution.

.....
.....
.....
.....
.....
.....
..... [2]

- (d) In an experiment, a spatula of potassium nitrate was added to 50 cm³ of water in a beaker.

The mixture was stirred to make a solution and the temperature of contents in the beaker changed from 20.4 °C to 18.7 °C.

- (i) Determine if this change is endothermic or exothermic.

..... [1]

- (ii) The enthalpy change of solution can be calculated using the given formula.

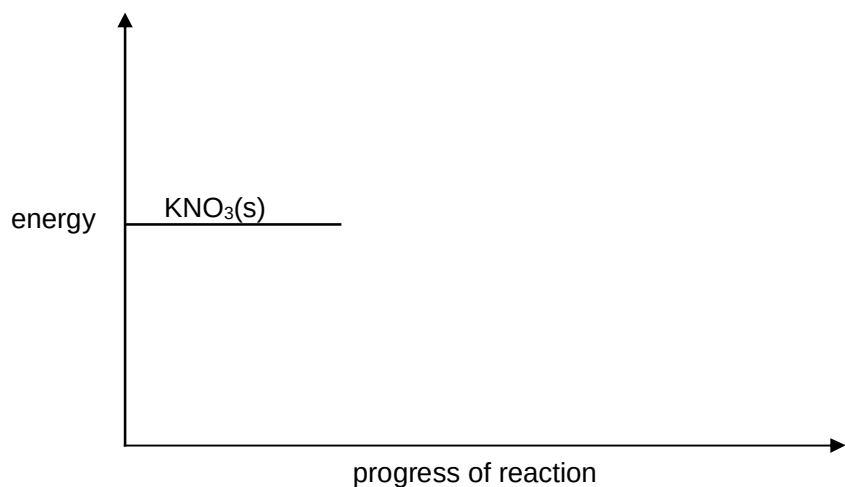
$$\Delta H = c \times m \times \Delta T$$

- The specific heat capacity of water, c , is 4.2 kJ per kg per °C.
- The mass of 50 cm³ of water, m , is 0.050 kg.

Calculate the enthalpy change in kJ for this experiment.

enthalpy change kJ [1]

- (iii) Complete the energy level diagram to show the product and energy change of solution when potassium nitrate dissolves in water.



[1]

[Total: 8]

6 Table 6.1 shows information about two electrolysis experiments.

Table 6.1

experiment	electrolyte	electrode	ionic equation for reaction at electrode
1	dilute $\text{CuSO}_4(\text{aq})$	at negative graphite electrode	
		at positive graphite electrode	
2	dilute $\text{CuSO}_4(\text{aq})$	at negative copper electrode	
		at positive copper electrode	

(a) Complete Table 6.1. [3]

(b) In terms of bonding, explain the electrical conductivity of graphite.

.....

 [2]

(c) Describe any changes in the colour and pH of the electrolyte in experiments 1 and 2.

.....
 [1]

(d) The initial mass of one of the copper electrodes was 50 g.

After an hour, the mass of the copper electrode was 53 g.

What was the total number of moles of electrons which flowed through the circuit?

moles of electrons [2]

[Total: 8]

- 7 Transition metals and their compounds are good catalysts for many reactions, both in the laboratory and industry.

(a) State one **other** property of transition metals.

..... [1]

(b) Table 7.1 shows some examples of catalysts used in the industry.

Table 7.1

industrial process	manufacture	catalyst
Contact process	sulfuric acid	vanadium(V) oxide
Haber process	ammonia	iron
Ostwald process	nitric acid	platinum

All three industrial processes involve a reversible reaction.

(i) What is meant by a *reversible reaction*?

..... [1]

(ii) State **two** other conditions used in the Haber process.

..... [1]

(c) Suggest why many catalysts are used in powdered form.

.....
..... [1]

(d) Describe and explain, in terms of collisions between reacting particles, the effect of increasing the temperature on the rate of reaction.

.....
.....
.....
.....
..... [2]

(e) Refer to Table 7.1 to suggest **two** reasons why industries do not necessarily increase the temperature.

.....
..... [2]

[Total: 8]

8 Refining petroleum (crude oil)

Petroleum is a mixture of hydrocarbons and refining it is a complex process that involves transforming the mixture into various useful products through a series of complex processes. The initial step, fractional distillation, separates petroleum into different fractions such as petrol (gasoline), naphtha, kerosene (paraffin) and diesel.

Further refining processes, such as catalytic cracking and reforming, break down larger hydrocarbon molecules into smaller, more useful ones or rearrange their structures to enhance quality and performance. For example, naphtha undergoes cracking to form petrol and other fractions containing smaller alkanes and alkenes. Naphtha also undergoes reforming to restructure the straight-chain alkanes into branched-chain alkanes, cycloalkanes, and aromatic hydrocarbons. Hydrogen is produced as a by-product of the reactions.

These many processes yield several petroleum fractions, each tailored to meet specific market demands, from fuels essential for transportation and heating to feedstocks for the petrochemical industry, which are used in the production of plastics, synthetic fibers, and other materials.

Use of plastic materials (polymers)

Plastic materials are composed of long chains of repeating units called monomers. These materials are synthesized through polymerisation, where monomers chemically bond to form extensive networks. The diversity of plastics arises from the wide variety of monomers and polymerisation methods, resulting in an array of polymers with distinct properties tailored for specific applications. Table 8.1 gives some information about five important polymers.

Table 8.1

polymer	density in kg / m ³	maximum useable temperature / °C	solubility in organic solvents
low density poly(ethene)	920	85	soluble above 80 °C
high density poly(ethene)	960	120	soluble above 80 °C
poly(phenylethene)	1050	65	soluble
poly(chloroethene)	1390	60	soluble
poly(propene)	900	150	insoluble

The maximum usable temperature refers to the highest temperature at which a plastic material can continuously operate without experiencing significant degradation of its mechanical properties, physical structure or performance. Different plastics have varying maximum usable temperatures, influenced by their molecular structure and composition.

Plastics' lightweight, durability and cost-effectiveness have revolutionised numerous industries, including construction, healthcare, electronics and consumer goods. However, the widespread use of plastics also poses environmental challenges, emphasizing the need for sustainable practices to better manage plastic waste.

- (a) Describe and explain how the process of fractional distillation separates petroleum into fractions.

.....

.....

.....

.....

.....

..... [2]

- (b) Table 8.2 shows the uses of fractions obtained from petroleum.

Table 8.2

fraction	use
petrol	fuel for cars
naphtha	petrochemical feedstock
kerosene	
diesel	

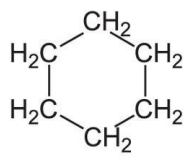
- (i) Complete Table 8.2. [1]

- (ii) Name one **other** fraction obtained from petroleum.

..... [1]

- (c) Table 8.3 shows information about two processes.

Table 8.3

process	equation	structure of a product
A	$C_6H_{14} \rightarrow C_6H_{12} + H_2$	
B	$C_6H_{14} \rightarrow C_3H_6 + C_2H_4 + CH_4$	

- (i) Complete Table 8.3 by drawing the **full** structure of **one** of the products. [1]

- (ii) Identify which process is cracking and which is reforming by circling the correct answers.

process A cracking / reforming

process B cracking / reforming

[1]

- (d) Which polymer, given in Table 8.1, would be most suited for making a pipe to carry lubricating oil at 100 °C?

Give **two** reasons for your answer.

.....
.....
.....
..... [2]

- (e) Poly(propene) is made from the monomer propene.

Draw the structure of poly(propene).

[1]

- (f) State the structure and bonding in plastics.

.....
..... [1]

- (g) (i) Describe **one** method of recycling plastics.

.....
..... [1]

- (ii) Discuss **one** challenge of recycling plastics.

.....
..... [1]

[Total: 12]

- 9 The NASA space shuttle uses fuel cells to generate electricity.

Fig. 9.1 shows a hydrogen fuel cell.

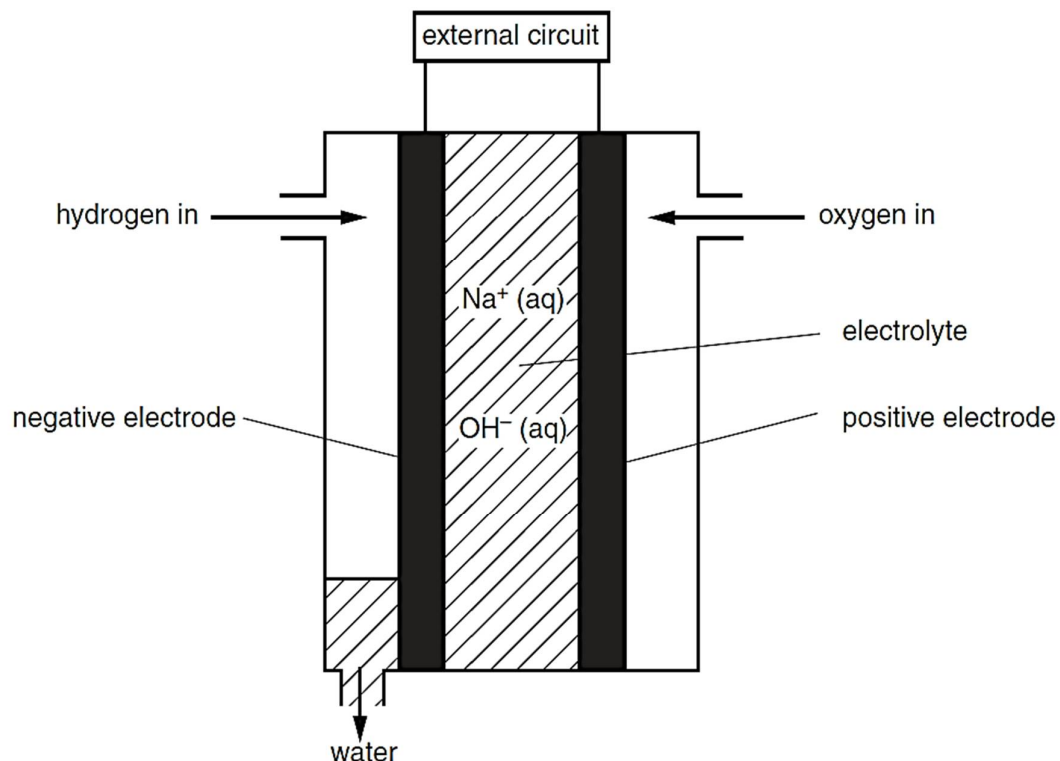
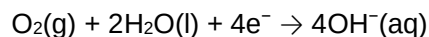
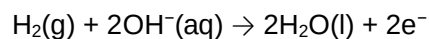


Fig. 9.1

At the positive electrode, oxygen reacts with water.



At the negative electrode, hydrogen reacts with hydroxide ions.



- (a) Write the overall chemical equation of the reaction taking place in a hydrogen fuel cell.

..... [1]

- (b) A fuel cell uses 250 dm³ of hydrogen.
Calculate the minimum volume of oxygen needed in this fuel cell.

volume of oxygen dm³ [1]

- (c) What type of reaction, reduction or oxidation, takes place at the positive electrode?
Explain your answer.

.....

..... [1]

- (d) Name the electrolyte used in Fig. 9.1 and explain its electrical conductivity.

.....
..... [1]

- (e) Give **two** disadvantages of using hydrogen as a fuel to generate electricity.

.....
..... [2]

- (f) Hydrogen and biofuels are renewable energy sources, offering viable alternatives to fossil fuels. Hydrogen, produced through electrolysis powered from renewable sources, is a potential clean fuel of the future, as it does not have any direct greenhouse gas emissions. Not only does it have less environmental impact, but it also has higher energy density and efficiency.

Biofuels, derived from inorganic materials such as plastic waste and metals, involve practices that exhaust natural resources and cause ecological damage. They increase greenhouse gas emissions since the carbon dioxide released during their combustion is not offset by the carbon dioxide absorbed during their production process. Biofuels, however, do not require oxygen to burn, as they generally have higher oxygen content in their molecular structure compared to fossil fuels.

Complete the table by identifying and correcting **two** errors in the description of hydrogen and biofuels.

error	corrections to error

[2]

[Total: 8]

Section B

Answer **one** question from this section.

- 10** Alcohols have a variety of uses. While ethanol is most recognised for its presence in alcoholic drinks, many alcohols are key solvents in the production of pharmaceuticals, perfumes, and cosmetics due to their ability to dissolve different substances.

The smallest alcohols, methanol, ethanol and propanol, are miscible in water. The larger the alcohol molecule, the lower the miscibility. However, the melting and boiling points of alcohols increase with increasing molecular size, due to stronger intermolecular forces of attraction.

- (a) Use the information to give **one** piece of evidence that alcohols are a homologous series.

.....
..... [1]

- (b) State the general formula of alcohols.

..... [1]

- (c) Draw the structure of **two** isomers of propanol.

[2]

- (d) In an experiment, 5 g of ethanol was heated with 5 g of ethanoic acid in the presence of a few drops of concentrated sulfuric acid.

- (i) Name the products of this reaction.

..... [1]

- (ii) What is the mass of the organic product formed given that the yield is 60%?

mass of organic product [3]

- (e) Ester and amide linkages can be hydrolysed by warming in any acidic or alkaline solution.

Fig. 10.1 shows the structure of compound X, which is an amide.

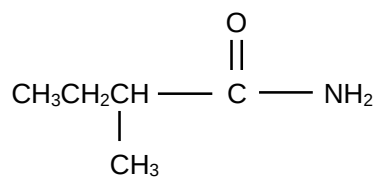


Fig. 10.1

Draw the structures of the products of hydrolysis of compound X.

[2]

[Total: 10]

- 11** Table 11.1 gives information about the first five members of the homologous series of carboxylic acids.

Table 11.1

name of acid	formula	relative molecular mass	melting point / °C	boiling point / °C
methanoic acid	HCO ₂ H	46	8.4	101
ethanoic acid	CH ₃ CO ₂ H	60	17	118
propanoic acid	C ₂ H ₅ CO ₂ H	74	-22	141
butanoic acid	C ₃ H ₇ CO ₂ H	88	-8	164
pentanoic acid				

- (a)** Predict the formula and the relative molecular mass for pentanoic acid.

..... [1]

- (b)** Is it easier to predict the melting or boiling point of pentanoic acid?
Explain your answer.

.....

 [2]

- (c)** Draw the displayed formula for propanoic acid.

[1]

- (d)** Describe how ethanoic acid is prepared in the laboratory.

Include any reagents and conditions required, as well as expected observations.

.....

 [2]

- (e) A fatty acid is made up of a carboxyl group and a hydrocarbon chain.

Fatty acids can be classified as saturated, monounsaturated or polyunsaturated.

- (i) Describe a chemical test that can be used to distinguish between a saturated fatty acid and an unsaturated fatty acid.

.....
.....
.....
.....
..... [2]

- (ii) A fat molecule consists of fatty acids and glycerol.

Fig. 11.1 shows the structure of compound X, which is a fat molecule.

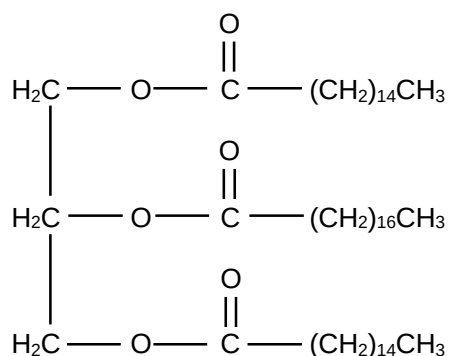


Fig. 11.1

Draw the structures of **two** fatty acids formed by hydrolysis of compound X.

[2]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
Key proton (atomic) numbers atomic symbol name relative atomic mass							1 H hydrogen 1										He helium 4
												5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
												13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
3 Li lithium 7	4 Be beryllium 9																
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12						
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs c 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium 209	85 At astatine 210	86 Rn r 222
Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganeson –

lanthanoids

actinoids

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 162	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of any gas is 24 dm³ at room temperature and pressure (r.t.p.)

The Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$.