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CHEMISTRY **0620/43**

Paper 4 Theory (Extended) **May/June 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

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1 Name the process used to:

(a) produce ammonia from nitrogen

View solution

..... [1]

(b) produce lead from molten lead(II) bromide

View solution

..... [1]

(c) separate an insoluble solid from a mixture of an insoluble solid and a solution

View solution

..... [1]

(d) produce ethanol from ethene

View solution

..... [1]

(e) identify the components of a mixture of soluble coloured substances

View solution

..... [1]

(f) separate a mixture of several liquids with different boiling points

View solution

..... [1]

(g) determine the volume of an acid required to neutralise a given volume of an alkali.

..... [1]

[Total: 7]

View solution

2 Complete Table 2.1.

View solution

Table 2.1

atom or ion	number of protons	number of electrons	number of neutrons
$^{63}_{29}Cu$	29		
$^{37}_{17}Cl^{-}$			20
	30	28	34

[5]

3 This question is about elements and compounds.

(a) Some properties of graphite, oxygen and carbon monoxide are shown in Table 3.1.

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Table 3.1

	melting point / °C	boiling point / °C	conduction of electricity when solid
graphite	3652	4827	good
oxygen	–218	–183	poor
carbon monoxide	–199	–191	poor

(i) Explain why graphite conducts electricity when solid.

.....

..... [1]

(ii) Complete the dot-and-cross diagram in Fig. 3.1 of a molecule of oxygen.

Show outer shell electrons only.

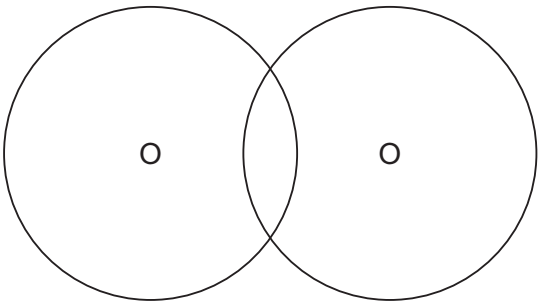

Fig. 3.1

[2]

(iii) Deduce the physical state of carbon monoxide at –195 °C. Use the data in Table 3.1 to explain your answer.

physical state .....

explanation .....

.....

[2]

(iv) Explain in terms of structure and bonding why graphite has a much higher melting point than carbon monoxide.

.....

.....

.....

..... [3]

View solution

(b) Potassium reacts with chlorine to form potassium chloride.

Write a symbol equation for this reaction.

..... [2]

View solution

(c) A dilute aqueous solution of potassium chloride undergoes electrolysis.

Oxygen is produced at the anode.

(i) State what is meant by the term electrolysis.

.....

.....

..... [2]

(ii) Write an ionic half-equation for the production of oxygen at the anode.

..... [2]

[Total: 14]

View solution

4 Dinitrogen tetroxide, N_2O_4, decomposes into nitrogen dioxide, NO_2.The reaction is reversible.

$$\underset{\text{colourless gas}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown gas}}{2NO_2(g)}$$

Fig. 4.1 shows a gas syringe containing a mixture of dinitrogen tetroxide and nitrogen dioxide. The gas syringe is sealed. The mixture reaches equilibrium and the colour of the mixture of gases is a pale brown.

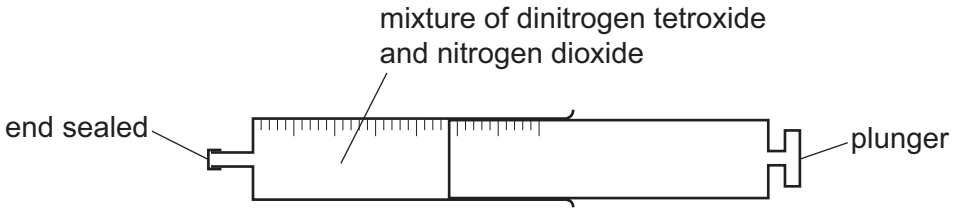

Fig. 4.1

(a) Describe a reversible reaction at equilibrium in terms of:

View solution

- the rate of the forward reaction and the rate of the reverse reaction

.....

- the concentration of reactants and products.

.....

[2]

(b) The pressure of the mixture is increased. All other conditions stay the same.

View solution

The mixture immediately turns darker brown before the position of equilibrium changes.

Explain in terms of particles why the mixture immediately turns darker brown.

..... [1]

(c) The temperature of the mixture is increased. All other conditions stay the same.

View solution

The mixture turns darker brown.

State what can be deduced about the forward reaction from this information.

..... [1]

(d) Sulfur is converted into sulfuric acid, H_2SO_4, by a series of reactions.

Sulfur dioxide, SO_2, and oxygen, O_2, react to form sulfur trioxide, SO_3. The reversible reaction reaches equilibrium.

View solution

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Complete Table 4.1 using only the words, **increases**, **decreases** or **no change**.

Table 4.1

	effect on the rate of the forward reaction	effect on the equilibrium yield of $SO_3(g)$
add a catalyst		
increase the pressure		

[4]

View solution

(ii) Deduce the oxidation number of sulfur in:

S .....

SO_3 .....

[2]

[Total: 10]

5 **(a)** Barium sulfate, $BaSO_4$, is an insoluble salt and is made by precipitation.

(i) Name **two** aqueous solutions that produce a precipitate of barium sulfate when they are mixed.

1 .....

2 .....
[2]

(ii) Describe how to produce a pure sample of barium sulfate from the mixture of aqueous solutions in **(a)(i)**.

.....

..... [2]

(iii) Write an ionic equation for the precipitation reaction which produces barium sulfate. Include state symbols.

..... [3]

View solution

(b) Soluble salts are made from dilute acids.

Name the dilute acid and one other substance that react together to make copper(II) sulfate.

dilute acid .....

other substance .....
[2]

View solution

(c) Nitrates decompose when they are heated.

When hydrated copper(II) nitrate is heated, oxygen gas is produced.

(i) Describe a test for oxygen.

test .....

observations .....
[1]

(ii) Complete the equation for the decomposition of hydrated copper(II) nitrate.

$$2Cu(NO_3)_2 \bullet 3H_2O \rightarrow .....CuO + ...NO_2 + O_2 + ...H_2O$$ [2]

View solution

(d) Hydrated zinc sulfate gives off water when it is heated.

View solution

$$ZnSO_4 \bullet \mathbf{x}H_2O(s) \rightarrow ZnSO_4(s) + \mathbf{x}H_2O(g)$$

A student does an experiment to determine the value of **x** in $ZnSO_4 \bullet \mathbf{x}H_2O$.

step 1 The student weighs a sample of hydrated zinc sulfate.

step 2 The student heats the sample of hydrated zinc sulfate.

step 3 The student weighs the solid after heating.

step 4 The student repeats **step 2** and **step 3** until the mass of solid after heating is constant.

(i) State why the student does **step 4**.

..... [1]

(ii) In an experiment, 0.574 g of $ZnSO_4 \bullet \mathbf{x}H_2O$ is heated until the mass is constant.

View solution

The mass of $ZnSO_4$ that remains is 0.322 g.

[M_r: $ZnSO_4$, 161; H_2O, 18]

Determine the value of **x** using the following steps.

- Calculate the number of moles of $ZnSO_4$ remaining.

..... mol

- Calculate the mass of H_2O given off.

..... g

- Calculate the number of moles of H_2O given off.

..... mol

- Determine the value of **x**.

x = ...
[4]

[Total: 17]

6 This question is about iron.

(a) Fig. 6.1 shows a blast furnace used to extract iron from its ore.

View solution

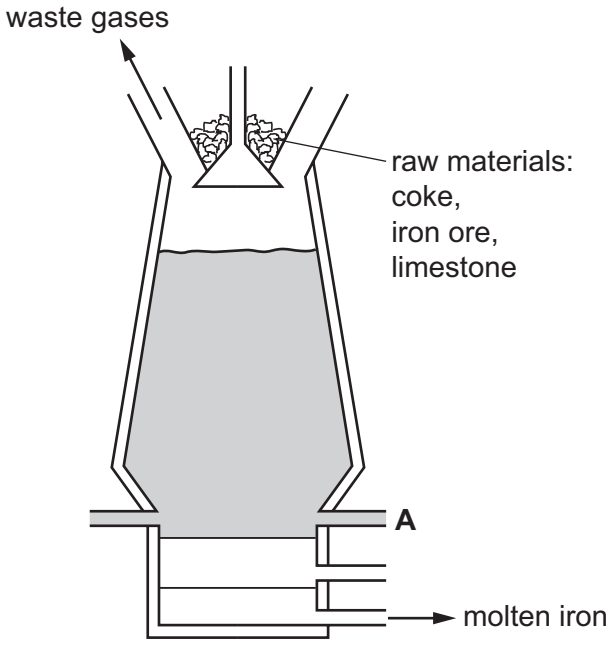

Fig. 6.1

(i) Name the main ore of iron used in the blast furnace.

..... [1]

(ii) Name the substance that enters the blast furnace at **A**.

View solution

..... [1]

(iii) Name the reducing agent in the extraction of iron in the blast furnace.

View solution

..... [1]

(iv) Explain why limestone is added to the blast furnace. Give details of the chemical reactions that are involved.

.....

.....

.....

..... [3]

View solution

(b) The list shows the properties of some elements.

View solution

- act as catalysts
- have low densities
- have low melting points
- form acidic or basic oxides
- form coloured compounds
- form positive or negative ions

Iron is a transition metal. Sodium is a Group I metal.

State which property from the list:

(i) is true for sodium but **not** iron

..... [1]

(ii) is true for iron but **not** sodium View solution

..... [1]

(iii) is true for both sodium and iron View solution

..... [1]

(iv) is **not** true for sodium and **not** true for iron.

..... [1]

View solution

(c) Steel consists mainly of iron.

View solution

Iron rusts when it reacts with water and oxygen.

Fig. 6.2 shows magnesium blocks attached to the bottom of a steel boat. The magnesium does **not** completely cover the steel.

The magnesium blocks provide sacrificial protection for the steel.

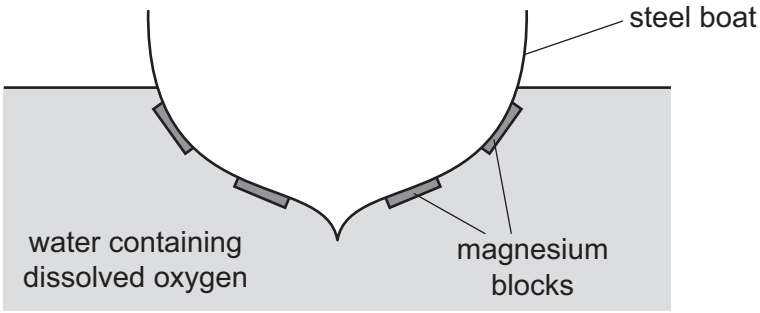

Fig. 6.2

(i) Explain, in terms of electrons, why magnesium is used for sacrificial protection.

.....

..... [2]

(ii) Name a metal that cannot provide sacrificial protection for steel.

..... [1]

[Total: 13]

View solution

7 Many organic compounds contain carbon and hydrogen only.

(a) (i) An organic compound **A** has the following composition by mass.

View solution

C, 83.33%; H, 16.67%

Calculate the empirical formula of compound **A**.

empirical formula = ... [3]

(ii) Compound **B** has the empirical formula C_2H_5 and a relative molecular mass of 58.

View solution

Determine the molecular formula of compound **B**.

molecular formula = ... [2]

(b) Fig. 7.1 shows a section of a polymer formed from an alkene.

View solution

(i) Identify the functional group in alkenes that reacts when alkenes form polymers.

..... [1]

(ii) A section of a polymer is shown in Fig. 7.1.

View solution

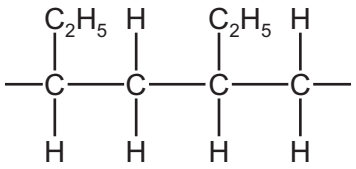

Fig. 7.1

- Draw the displayed formula of the monomer that forms this polymer.

- Name the monomer used to form this polymer.

.....
[3]

(c) Alkenes are produced by cracking alkanes.

When $C_{12}H_{26}$ is cracked, the products are ethene and an alkane which form in a 2 : 1 mole ratio.

Write a symbol equation for this reaction.

View solution 

$C_{12}H_{26} \rightarrow$ ..... + ... [2]

(d) (i) State the general formula for alcohols.


View solution

..... [1]

(ii) Draw the displayed formula of **one** alcohol with the molecular formula C_3H_8O. Name the alcohol you have drawn.


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name of alcohol .....

[2]

[Total: 14]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											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
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 caesium 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 –	85 At astatine –	86 Rn radon –
87 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 oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

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 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 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 one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).