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0620/41

October/November 2023

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.



1 A list of gases is shown.

ammonia
carbon dioxide
carbon monoxide
ethene
fluorine
oxygen
sulfur dioxide
xenon

Answer the following questions using only the gases from the list.
Each gas may be used once, more than once or not at all.

Give the name of the gas that:

(a) causes acid rain

..... [1]

(b) forms an alkaline solution when dissolved in water

..... [1]

(c) is inert

..... [1]

(d) is a product of photosynthesis

..... [1]

(e) can form a polymer

..... [1]

(f) is produced in the test for nitrate ions.

..... [1]

[Total: 6]

2 Boron and aluminium are Group III elements.

(a) Boron has only two naturally occurring isotopes, ^{10}B and ^{11}B .

Complete Table 2.1 to show the numbers of protons, neutrons and electrons in an atom of ^{11}B .

Table 2.1

number of protons	number of neutrons	number of electrons

[2]

(b) The relative atomic mass of boron to one decimal place is 10.8.

(i) Determine the relative abundance of ^{10}B present in boron. Give your answer as a percentage.

..... % [1]

(ii) Use the relative atomic mass of boron to calculate the number of atoms in 0.540 g of boron. Give your answer in standard form.

number of atoms = [2]

(c) Aluminium is extracted from its purified ore as shown in Fig. 2.1.

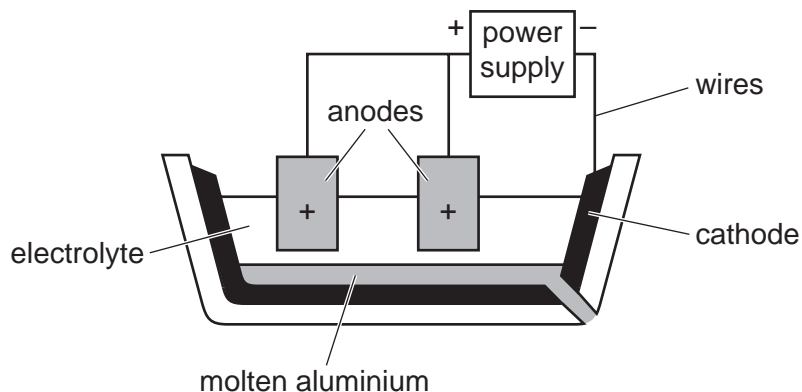


Fig. 2.1

(i) Name the ore of aluminium.

..... [1]

(ii) The electrolyte contains aluminium oxide and one other substance.

Name the other substance and explain why it is used.

name

explanation

..... [2]

(iii) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(iv) Explain why the anodes need frequent replacement.

.....

..... [2]

(d) State **two** physical properties of aluminium that make it suitable for use in overhead electrical cables.

1

2

[2]

(e) Explain the apparent unreactivity of aluminium.

.....
 [2]

(f) Aluminium reacts with fluorine to form aluminium fluoride, AlF_3 , an ionic compound.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) Complete Fig. 2.2 to show the electronic configuration of one aluminium ion and one fluoride ion.
 Show the charges on the ions.

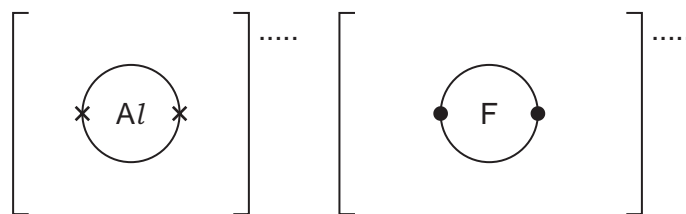


Fig. 2.2

[3]

[Total: 21]

3 Order of reactivity can be determined by displacement reactions.

(a) A student investigates the reactivities of four metals by carrying out a series of experiments.

Each of the metals lead, manganese, silver and zinc are added separately to aqueous metal nitrates of the other metals.

(i) Table 3.1 shows some of the results.

Table 3.1

aqueous solution	lead Pb	manganese Mn	silver Ag	zinc Zn
lead(II) nitrate		✓		
manganese(II) nitrate				
silver nitrate	✓	✓		✓
zinc nitrate	x	x		

key

✓ = displacement reaction occurs

x = displacement reaction does not occur

Complete Table 3.1 and place the four metals in their order of reactivity with the most reactive first.

1 most reactive

2

3

4

[3]

(ii) Suggest why the metal nitrates and not the metal sulfates of these four metals are used as the aqueous solutions.

..... [1]

(iii) Write the symbol equation for the reaction between zinc and silver nitrate.

..... [2]

- (b) The reactivity of Group VII elements can be investigated experimentally.

A student bubbles chlorine gas into a test-tube containing aqueous potassium bromide.

- (i) Describe the colour change seen in the test-tube.

from to [2]

- (ii) Complete the ionic equation for this reaction.

Include state symbols.

..... +Br⁻(aq) → + [3]

- (iii) The reactivity trend seen in Cl, Br and I applies to all the elements in Group VII.

Use the Periodic Table to identify the Group VII element which **cannot** displace any other Group VII elements.

..... [1]

[Total: 12]

- 4 Aqueous hydrogen peroxide, H_2O_2 , slowly forms water and oxygen at room temperature and pressure, r.t.p. This reaction is catalysed by manganese(IV) oxide.

The equation is shown.



- (a) State the test for oxygen gas.

test

observations

[1]

- (b) A student investigates the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide.

The volume of oxygen gas formed is measured at regular time intervals at r.t.p. The results are plotted onto the graph in Fig. 4.1.

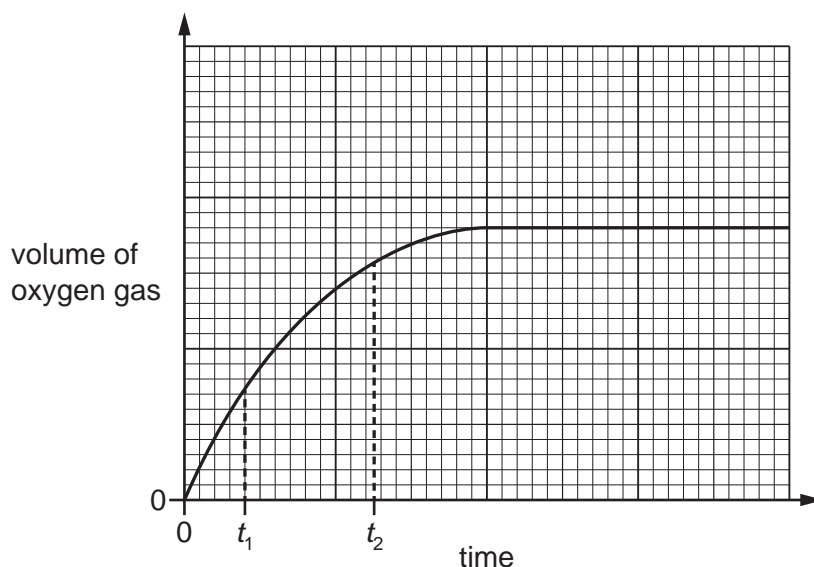


Fig. 4.1

- (i) State how the graph in Fig. 4.1 shows the rate of reaction at time t_2 , is lower than at time t_1 .

..... [1]

- (ii) Explain, using collision theory, why the rate of reaction at time t_2 is lower than at time t_1 .

.....

.....

..... [2]

- (iii) On Fig. 4.1, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [2]

- (c) Manganese(IV) oxide is added to 20 cm³ of aqueous hydrogen peroxide. The total volume of oxygen gas produced is 72 cm³ at r.t.p.



Calculate the concentration of the aqueous hydrogen peroxide in g/dm³ using the following steps.

- Calculate the number of moles of oxygen gas produced.

..... mol

- Determine the number of moles of hydrogen peroxide which reacts.

..... mol

- Calculate the concentration of aqueous hydrogen peroxide in mol/dm³.

..... mol/dm³

- Calculate the concentration of aqueous hydrogen peroxide in g/dm³.

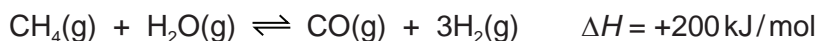
..... g/dm³
[5]

- (d) Suggest the identity of one **other** metal oxide which also catalyses this reaction.

..... [1]

[Total: 12]

- 5 Methane reacts with steam to produce hydrogen gas.



The reaction takes place at 1000 °C and 100 kPa pressure.

- (a) The reaction is reversible and reaches an equilibrium in a closed system.

State **two** features of an equilibrium.

1

2 [2]

- (b) State and explain, in terms of equilibrium, what happens to the concentration of hydrogen when:

- (i) the pressure is increased

.....

..... [2]

- (ii) the temperature is increased

.....

..... [2]

- (iii) a catalyst is used.

.....

..... [2]

- (c) Methane is a greenhouse gas which contributes to global warming.

- (i) Name a greenhouse gas found in clean, dry air.

..... [1]

- (ii) Explain, in terms of thermal energy, how greenhouse gases cause global warming.

.....

.....

.....

.....

..... [3]

[Total: 12]

6 Ethanol is manufactured by **two** methods:

method 1 fermentation of aqueous glucose

method 2 catalytic addition of steam to an alkene.

(a) Method 1 takes place at room temperature and pressure.

State **two** other conditions needed in method 1.

1

2

[2]

(b) (i) State the typical temperature and pressure used in method 2.

temperature °C

pressure kPa

[2]

(ii) Name the alkene used in method 2.

..... [1]

(iii) State why the reaction in method 2 is referred to as an addition reaction.

..... [1]

(c) The catalyst in method 2 is phosphoric acid, H_3PO_4 . Dilute phosphoric acid is a weak acid which contains phosphate ions, PO_4^{3-} .

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

..... [1]

(ii) State the meaning of weak in the term weak acid.

..... [1]

(iii) Determine the oxidation number of phosphorus in the PO_4^{3-} ion.

Show your working.

oxidation number = [2]

(d) Give **one** advantage of each method of production of ethanol.

method 1

method 2 [2]

(e) Ethanol can be converted to ethanoic acid by reacting it with an acidified oxidising agent.

(i) Name the acidified oxidising agent.

..... [1]

(ii) State, in terms of redox, what type of reagent ethanol is in this reaction.

..... [1]

(f) Ethanoic acid reacts with calcium to form a salt and one other product.

(i) Name the salt.

..... [1]

(ii) Write the formula of the salt.

..... [1]

(iii) Identify the other product.

..... [1]

[Total: 17]

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The Periodic Table of Elements

Group																		
I	II	Key										III	IV	V	VI	VII	VIII	
		<div>1Hhydrogen1</div>																
3Li lithium 7	4Be beryllium 9	<div>atomic number atomic symbol name relative atomic mass</div>										5B boron 11	6C carbon 12	7N nitrogen 14	8O oxygen 16	9F fluorine 19	10Ne neon 20	
11Na sodium 23	12Mg magnesium 24											13Al aluminium 27	14Si silicon 28	15P phosphorus 31	16S sulfur 32	17Cl chlorine 35.5	18Ar argon 40	
19K potassium 39	20Ca calcium 40	21Sc scandium 45	22Ti titanium 48	23V vanadium 51	24Cr chromium 52	25Mn manganese 55	26Fe iron 56	27Co cobalt 59	28Ni nickel 59	29Cu copper 64	30Zn zinc 65	31Ga gallium 70	32Ge germanium 73	33As arsenic 75	34Se selenium 79	35Br bromine 80	36Kr krypton 84	
37Rb rubidium 85	38Sr strontium 88	39Y yttrium 89	40Zr zirconium 91	41Nb niobium 93	42Mo molybdenum 96	43Tc technetium —	44Ru ruthenium 101	45Rh rhodium 103	46Pd palladium 106	47Ag silver 108	48Cd cadmium 112	49In indium 115	50Sn tin 119	51Sb antimony 122	52Te tellurium 128	53I iodine 127	54Xe xenon 131	
55Cs caesium 133	56Ba barium 137	57–71 lanthanoids		72Hf hafnium 178	73Ta tantalum 181	74W tungsten 184	75Re rhenium 186	76Os osmium 190	77Ir iridium 192	78Pt platinum 195	79Au gold 197	80Hg mercury 201	81Tl thallium 204	82Pb lead 207	83Bi bismuth 209	84Po polonium —	85At astatine —	86Rn radon —
87Fr francium —	88Ra radium —	89–103 actinoids		104Rf rutherfordium —	105Db dubnium —	106Sg seaborgium —	107Bh bohrium —	108Hs hassium —	109Mt meitnerium —	110Ds darmstadtium —	111Rg roentgenium —	112Cn copernicium —	113Nh nihonium —	114Fl flerovium —	115Mc moscovium —	116Lv livermorium —	117Ts tennessine —	118Og 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 163	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 one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).