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CHEMISTRY

0620/42

Paper 4 Theory (Extended)

February/March 2021

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 **12** pages. Any blank pages are indicated.



1 The table shows the numbers of protons, neutrons and electrons in particles **A** to **I**.

particle	protons	neutrons	electrons
A	1	0	0
B	6	6	6
C	6	8	6
D	10	10	10
E	16	16	18
F	17	18	17
G	18	22	18
H	19	20	19
I	20	20	18

Answer the following questions about particles **A** to **I**. Each letter may be used once, more than once or not at all.

(a) State which of the particles **A** to **I**:

- (i) is an anion [1]
- (ii) are cations and [2]
- (iii) are noble gas atoms and [2]
- (iv) is a halogen atom [1]
- (v) is a Group I atom [1]
- (vi) have the same nucleon number and [1]
- (vii) causes acidity in aqueous solutions [1]
- (viii) is used to define the relative atomic mass of elements. [1]

(b) Explain why **B** and **C** are isotopes of the same element.

.....
 [2]

[Total: 12]

2 The elements shown are gases at room temperature and pressure.

hydrogen
nitrogen
oxygen
chlorine

(a) State which **one** of these gases is green.

..... [1]

(b) The gases shown exist as diatomic molecules.

State the name of **another** element which has diatomic molecules and is a gas at room temperature and pressure.

..... [1]

(c) When separate samples of each of these gases are placed in a container they will diffuse.

(i) Describe why these gases diffuse.

..... [1]

(ii) State which of these four gases has the highest rate of diffusion.

Explain your answer.

gas

explanation

..... [2]

(d) Nitrogen, oxygen and other substances are found in clean, dry air.

(i) State the percentage of nitrogen in clean, dry air.

..... [1]

(ii) Other than nitrogen and oxygen, identify another element found in clean, dry air.

..... [1]

(iii) Identify a compound found in clean, dry air.

..... [1]

(iv) Nitrogen and oxygen can be separated from liquid air.

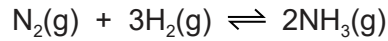
State the name of this process.

..... [2]

[Total: 10]

3 This question is about ammonia.

(a) Nitrogen reacts with hydrogen to form ammonia in an industrial process.



(i) Name this industrial process.

..... [1]

(ii) State the meaning of the symbol \rightleftharpoons .

..... [1]

(iii) State the conditions used in this industrial process. Include units.

temperature

pressure

[2]

(iv) Name the catalyst used in this industrial process.

..... [1]

(v) If the pressure is increased, the yield of ammonia increases.

Explain why, in terms of equilibrium.

.....

.....

..... [2]

(vi) If the temperature is increased, the rate of reaction increases.

Explain why, in terms of particles.

.....

.....

.....

.....

..... [3]

(b) Ammonia reacts with sulfuric acid to make a compound which is used as a fertiliser.

Write the chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 12]

4 A student wanted to make some zinc chloride crystals.

The student followed the procedure shown.

step 1 Add excess zinc powder to dilute hydrochloric acid to form aqueous zinc chloride.

step 2 Remove unreacted zinc powder from the aqueous zinc chloride.

step 3 Heat the solution until it is saturated.

step 4 Allow the saturated solution to cool and remove the crystals that form.

(a) Write the equation for the reaction in **step 1**. Include state symbols.

..... [3]

(b) Explain why **excess** zinc powder is added in **step 1**.

..... [1]

(c) Suggest how unreacted zinc powder is removed in **step 2**.

..... [1]

(d) A saturated solution is formed in **step 3**.

Suggest what is meant by the term *saturated solution*.

.....
 [2]

(e) Explain why crystals form as the solution cools in **step 4**.

..... [1]

(f) Name **two** zinc compounds which react with dilute hydrochloric acid to form zinc chloride.

.....
 [2]

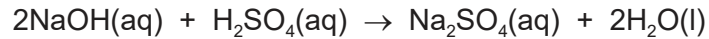
(g) If excess calcium metal is used instead of excess zinc powder in **step 1**, pure calcium chloride crystals do **not** form.

Explain why.

.....
 [1]

(h) Some salts can be made by titration.

In a titration experiment, 20.0 cm³ of aqueous sodium hydroxide reacts exactly with 25.0 cm³ of 0.100 mol/dm³ dilute sulfuric acid to make sodium sulfate.



(i) Circle the name of the type of reaction that takes place.

decomposition neutralisation precipitation reduction

[1]

(ii) Calculate the concentration of the aqueous sodium hydroxide in g/dm³ using the following steps.

- Calculate the number of moles of dilute sulfuric acid used.

..... mol

- Determine the number of moles of sodium hydroxide which react with the dilute sulfuric acid.

..... mol

- Calculate the concentration of the aqueous sodium hydroxide in mol/dm³.

..... mol/dm³

- Calculate the concentration of the aqueous sodium hydroxide in g/dm³.

..... g/dm³

[5]

[Total: 17]

QUESTION 5 STARTS ON THE NEXT PAGE.

5 The table shows the names or structures of organic compounds **P** to **U**.

P	Q	R
$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	propanoic acid	but-1-ene
S	T	U
propan-1-ol	methyl butanoate	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \diagdown \quad \quad \\ \text{C}=\text{C}-\text{C}-\text{H} \\ \diagup \quad \quad \\ \text{H} \quad \quad \text{H} \end{array} $

(a) Give the letters of the organic compounds, **P** to **U**, that are unsaturated hydrocarbons.

..... [2]

(b) Describe the test for an unsaturated hydrocarbon.

test

observations

[2]

(c) But-1-ene is an unbranched molecule.

(i) Name the unbranched isomer of but-1-ene.

..... [1]

(ii) Draw the structure of a branched isomer of but-1-ene. Show all of the atoms and all of the bonds.

[1]

(d) Dodecane is an alkane with 12 carbon atoms. Dodecane can be cracked.

(i) Write the formula of dodecane.

..... [1]

(ii) Give the letters of all the organic compounds, **P** to **U**, that can be formed when dodecane is cracked.

..... [2]

- (e) Name the reagent and suggest the conditions needed to convert organic compound **U** into organic compound **S**.

reagent

conditions

[3]

- (f) Organic compound **S** can be converted to organic compound **Q** by reaction with an acidified reagent.

- (i) Name the type of chemical change that happens to organic compound **S**.

..... [1]

- (ii) Name the acidified reagent added to organic compound **S**.

..... [1]

- (g) Organic compound **T** is made by reacting two compounds together.

- (i) Name the homologous series that organic compound **T** belongs to.

..... [1]

- (ii) Name the **two** compounds which react together to make organic compound **T**.

Draw the structures of each compound you have named. Show all of the atoms and all of the bonds.

name

structure

name

structure

[4]

- (iii) Deduce the molecular formula of organic compound **T**.

..... [1]

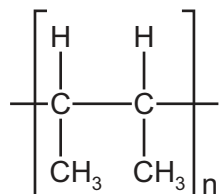
[Total: 20]

6 Polymers are large molecules built up from small molecules.

(a) State the name given to the small molecules from which polymers are made.

..... [1]

(b) The formula of a polymer is shown.



(i) Draw the structure of the small molecule from which this polymer is made. Show all of the atoms and all of the bonds.

[2]

(ii) State the type of polymerisation used to make this polymer.

..... [1]

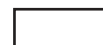
(c) Three amino acids are shown. They combine to form part of a natural polymer.



(i) Name the type of natural polymer formed when amino acids combine.

..... [1]

(ii) Complete the diagram to show part of the structure of the natural polymer that forms when these three amino acids combine. Show all of the bonds in the linkages.



[3]

(iii) Name the type of chemical reaction that takes place when this natural polymer is converted back to amino acids.

..... [1]

[Total: 9]

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The Periodic Table of Elements

		Group															
I	II	III	IV	V	VI	VII	VIII										
3 Li lithium 7	4 Be beryllium 9	1 H hydrogen 1	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	Key atomic number atomic symbol name relative atomic mass															
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 —	114 Fl flerovium —	116 Lv livermorium —	118 Og oganeson —	119 Uue unbinilium —	120 Uuo unbinilium —	121 Uuq unbinilium —

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
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 —

actinoids

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