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CHEMISTRY

0620/42

Paper 4 Theory (Extended)

February/March 2020

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

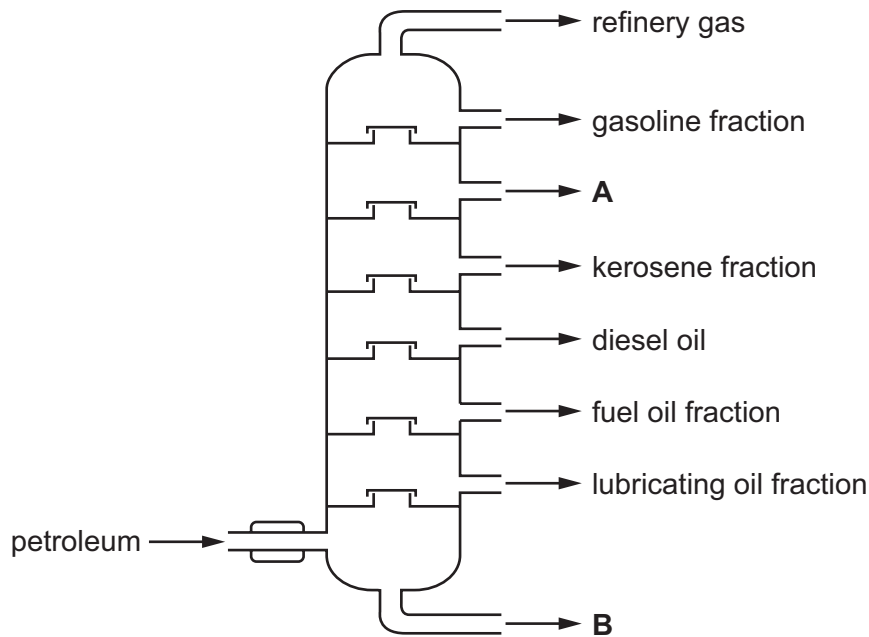
- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **12** pages. Blank pages are indicated.



1 Petroleum is a useful natural resource.

The diagram shows how petroleum can be separated into useful substances.



(a) What is the name of the separation process shown in the diagram?

..... [2]

(b) Name the fraction leaving at:

A

B

[2]

(c) Refinery gas is a mixture of hydrocarbons.

One refinery gas is butane, C_4H_{10} .

(i) Suggest the names of **two** other refinery gases.

..... and [2]

(ii) Write the chemical equation for the complete combustion of butane.

..... [2]

(iii) Name the toxic gas produced by the incomplete combustion of butane.

..... [1]

(d) Gasoline and kerosene are both fuels. They have different properties.

(i) Describe the differences in the properties given.

viscosity of the fuel

.....

flammability of the fuel

.....

[2]

(ii) What difference in the molecules of gasoline and kerosene causes these differences in properties?

..... [1]

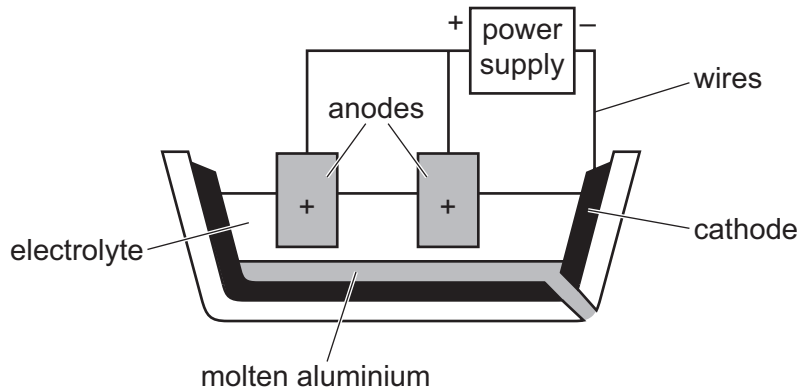
(e) Hydrogen fuel cells can be used to power vehicles.

Write the word equation for the overall reaction that takes place in a hydrogen fuel cell.

..... [1]

[Total: 13]

2 Aluminium is extracted from its ore. The ore is converted into pure aluminium oxide, which then undergoes electrolysis as shown.



(a) (i) Name an ore of aluminium.

..... [1]

(ii) What is meant by the term *electrolysis*?

.....
 [2]

(b) Aluminium oxide has a melting point of about 2000 °C, but the electrolysis process operates at about 900 °C.

(i) Name the compound added to aluminium oxide to reduce the operating temperature.

..... [1]

(ii) Suggest **one** benefit to the environment of reducing the operating temperature.

.....
 [1]

(iii) Write the ionic half-equation for the reaction taking place at:

the negative electrode (cathode)

the positive electrode (anode)

[4]

(iv) Explain why the anodes need frequent replacement.

.....
 [2]

(c) Aluminium oxide reacts with acids and with alkalis.

(i) What term is used to describe an oxide that reacts with acids and with alkalis?

..... [1]

(ii) Aluminium oxide reacts with dilute sulfuric acid to form a salt.

State the name and write the formula of the salt formed.

name

formula [2]

(iii) Aluminium oxide reacts with dilute sodium hydroxide to form a salt and one other product.

Name the other product.

..... [1]

(iv) Aluminium hydroxide, $Al(OH)_3$, decomposes when heated to form aluminium oxide and water.

Write the chemical equation for this reaction.

..... [2]

(v) Suggest the names of **two** other aluminium compounds that decompose when heated to form aluminium oxide.

.....

..... [2]

[Total: 19]

3 The Periodic Table is a method of classifying elements.

(a) Identify the element which is in Group VI and Period 4.

..... [1]

(b) Calcium is in Group II and chlorine is in Group VII of the Periodic Table.

Explain, in terms of number of outer shell electrons and electron transfer, how calcium atoms and chlorine atoms form ions. Give the formulae of the ions formed.

.....

 [5]

(c) Group V chlorides are covalent molecules. The boiling points of some Group V chlorides are shown.

chloride	boiling point/°C
NCl_3	71
PCl_3	
AsCl_3	130
SbCl_3	283

(i) Suggest the approximate boiling point of PCl_3 .

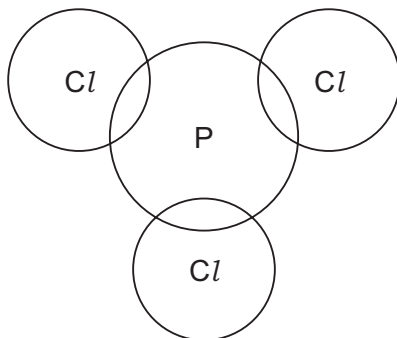
..... [1]

(ii) Explain the trend in boiling points in terms of attractive forces between particles.

.....
 [2]

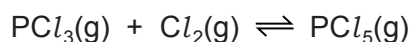
- (iii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of PCl_3 .

Show outer electrons only.



[3]

- (d) PCl_3 reacts with chlorine, Cl_2 , to form PCl_5 . This reaction is exothermic and reaches an equilibrium.



- (i) Describe **two** features of an equilibrium.

.....

 [2]

- (ii) State the effect, if any, on the position of this equilibrium when the following changes are made.
 Explain your answers.

temperature is increased

.....

pressure is increased

..... [4]

- (iii) Explain, in terms of particles, what happens to the rate of the forward reaction when the reaction mixture is heated.

.....

.....

.....

.....

..... [3]

(e) PCl_5 reacts with lithium fluoride, LiF, to form LiPF_6 .



Calculate the mass of LiF needed to form 3.04 g of LiPF_6 using the following steps.

- Calculate the number of moles of LiPF_6 formed.
[M_r : LiPF_6 , 152]

number of moles =

- Deduce the number of moles of LiF needed.

number of moles =

- Calculate the mass of LiF needed.

mass = g
[3]

(f) Lithium fluoride has ionic bonding.

- (i) What is an ionic bond?

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

- (ii) Give **two** physical properties of ionic compounds.

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

[Total: 28]

4 Iron is a typical transition element.

Iron:

- acts as a catalyst
- forms coloured compounds
- has more than one oxidation state.

(a) Name **one** major industrial process that uses iron as a catalyst and name the product made in this process.

process

product made

[2]

(b) When aqueous sodium hydroxide is added to aqueous iron(II) sulfate, a precipitate forms.

(i) What colour is this precipitate?

..... [1]

(ii) Write the ionic equation for this reaction. Include state symbols.

..... [3]

(c) Iron(II) sulfate can be converted to iron(III) sulfate by potassium manganate(VII) at room temperature.

(i) What is the role of potassium manganate(VII) in this reaction?

..... [1]

(ii) What condition must be used for this reaction to occur?

..... [1]

(iii) In terms of electron transfer, what happens to the iron(II) ions in this reaction?

..... [1]

(iv) State the colour change seen during this reaction.

from purple to [1]

(d) Deduce the charge on the iron ion in each of these compounds.

FeF_3

$\text{Fe}(\text{NO}_3)_3$

[2]

[Total: 12]

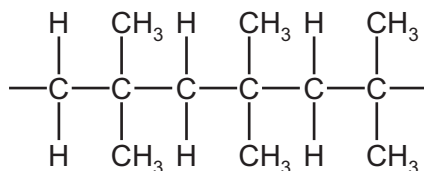
5 There are two types of polymers.

(a) Addition polymers are made from many identical small units.

(i) What is the term used to describe these small units?

..... [1]

(ii) A section of an addition polymer is shown.



Draw the structure of the small unit used to make this addition polymer.

Show all of the atoms and all of the bonds.

[2]

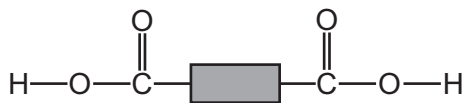
(b) Polyamides are condensation polymers.

What does the term *condensation* mean when used to describe this type of polymer?

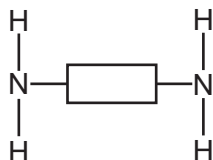
..... [1]

(c) A polyamide can be made from two different molecules.

A simplified structure of octanedioic acid is shown.



A simplified structure of 1,6-diaminohexane is shown.



(i) Complete the diagram to show a section of polyamide manufactured from octanedioic acid and 1,6-diaminohexane. Include all of the atoms and all of the bonds in the linkages.



[3]

(ii) State the name of a synthetic polyamide.

..... [1]

[Total: 8]

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The Periodic Table of Elements

		Group																																	
I	II	III	IV	V	VI	VII	VIII																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																		
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	Al aluminium 13	Si silicon 14	P phosphorus 15	S sulfur 16	Cl chlorine 17	Ar argon 18	K potassium 19	Ca calcium 20	Sc scandium 21	Ti titanium 22	V vanadium 23	Cr chromium 24	Mn manganese 25	Fe iron 26	Co cobalt 27	Ni nickel 28	Cu copper 29	Zn zinc 30	Ga gallium 31	Ge germanium 32	As arsenic 33	Se selenium 34	Br bromine 35	Kr krypton 36								
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57-71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 90	Nb niobium 91	Mo molybdenum 92	Tc technetium 93	Ru ruthenium 94	Rh rhodium 95	Pd palladium 96	Ag silver 97	Cd cadmium 98	In indium 99	Sn tin 100	Sb antimony 101	Te tellurium 102	I iodine 103	Xe xenon 104	Cs caesium 133	Ba barium 137	La lanthanum 139	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium 210	At astatine 210	Rn radon 222
87	88	89-103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
Fr francium —	Ra radium —	Ac actinium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Fl flerovium —	Lv livermorium —	Uu ununoctium —	Uub unubium —	Uut ununtrium —	Uuq ununquadium —	Uup ununpentium —	Uuq ununhexium —	Uus ununseptium —	Uuo ununoctium —	Uuh ununheptium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	Uuq ununquadium —	

Key

atomic number
atomic symbol
name
relative atomic mass

1
H
hydrogen
1

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 dm³ at room temperature and pressure (r.t.p.).