This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 02

19DEC2022

Do NOT write in this box. Your MARK will be placed here.

Subject :	A Level : Chemistry 1
Class :	11A and 12A
Teacher :	Mrs. Saydeh Nasrallah
Duration :	2 hours

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

SECTION A

Answer ALL the questions in this section.
You should aim to spend no more than 25 minutes on this section.
For each question, select one answer from A to D and put a cross in the box.
If you change your mind, put a line through ☒ the box and then mark your new answer with a cross. ☒

1. How many molecules are there in 44.0 g of carbon monoxide?
Avogadro constant $L = 6.02 \times 10^{23} mol^{-1}$

☐ **A** 3.83×10^{23}
☐ **B** 6.02×10^{23}
☐ **C** 9.46×10^{23}
☐ **D** 1.89×10^{24}

(Total for Question 1 = 1 mark)

2. A compound has $M_r = 84$ and its composition by mass is 71.4 % carbon, 9.6 % hydrogen and 19.0 % oxygen.
What is the molecular formula of this compound?

☐ **A** $C_4H_3O_2$
☐ **B** $C_4H_4O_2$
☐ **C** C_5H_8O
☐ **D** $C_6H_{10}O$

(Total for Question 2 = 1 mark)

3. Which of these compounds has the same empirical and molecular formulae?

☐ **A** C_2H_4
☐ **B** C_3H_8
☐ **C** C_4H_{10}
☐ **D** C_5H_{10}

(Total for Question 3 = 1 mark)

4. The equation for the complete combustion of hexane is shown.

$$C_6H_{14} + 9½\ O_2 \rightarrow 6CO_2 + 7H_2O$$

How many molecules of carbon dioxide are formed when $2 \times 10^{-3} mol$ of hexane undergoes complete combustion?
[Avogadro constant $L = 6.02 \times 10^{23} mol^{-1}$]

☐ **A** 1.20×10^{21}
☐ **B** 7.22×10^{21}
☐ **C** 8.43×10^{21}
☐ **D** 3.18×10^{23}

(Total for Question 4 = 1 mark)

5. Which of these solutions contains the greatest number of ions?

☐ **A** $20.0 cm^3$ of $0.5 mol\,dm^{-3}$ KCl
☐ **B** $0.40 dm^3$ of $0.03 mol\,dm^{-3}$ KCl
☐ **C** $10.0 cm^3$ of $0.6 mol\,dm^{-3}$ $CaCl_2$
☐ **D** $0.15 dm^3$ of $0.04 mol\,dm^{-3}$ $CaCl_2$

(Total for Question 5 = 1 mark)

6. What is the ionic equation for the reaction between aqueous solutions of barium nitrate and sodium sulfate?

☐ **A** $Na^+(aq) + NO_3\,{-}(aq) \rightarrow NaNO_3(s)$
☐ **B** $2Ba^+(aq) + SO_4{}^{2-}(aq) \rightarrow Ba_2SO_4(s)$
☐ **C** $Na^{2+}(aq) + 2NO_3{}^-(aq) \rightarrow Na(NO_3)_2(s)$
☐ **D** $Ba^{2+}(aq) + SO_4{}^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 6 = 1 mark)

7. The atomic number of the element scandium is 21 and the mass number of its only isotope is 45.
In a mass spectrometer, scandium forms Sc^+ and Sc^{2+} ions.
What is the m/z value for the mass spectrum peak due to the Sc^{2+} ions?

☐ **A** 22.5
☐ **B** 33.0
☐ **C** 45.0
☐ **D** 90.0

(Total for Question 7 = 1 mark)

8. Which equation represents the **second** ionisation energy of chlorine?

☐ **A** $Cl^-(g) + e^- \rightarrow Cl^{2-}(g)$
☐ **B** $Cl(g) + 2e^- \rightarrow Cl^{2-}(g)$
☐ **C** $2Cl(g) \rightarrow 2Cl^+(g) + 2e^-$
☐ **D** $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

(Total for Question 8 = 1 mark)

9. A mass of 0.23 g of sodium was added to $350 cm^3$ water to form hydrogen and a solution of sodium hydroxide.

$$Na(s) + H_2O(l) \rightarrow NaOH(aq) + \tfrac{1}{2}H_2(g)$$

What is the maximum volume, in cm^3, of hydrogen which could be formed, measured at r.t.p.? [Molar volume of a gas at r.t.p. = $24 dm^3 mol^{-1}$]

☐ **A** 120
☐ **B** 240
☐ **C** 480
☐ **D** 2800

(Total for Question 9 = 1 mark)

10. Ions with the same electronic configuration are said to be isoelectronic.
Which of the following compounds is made up of isoelectronic ions?

☐ **A** CaO
☐ **B** $CaBr_2$
☐ **C** Na_2O
☐ **D** LiF

(Total for Question 10 = 1 mark)

11. In which series are the ions in order of **decreasing** ionic radius?

☐ **A** $Al^{3+} > Mg^{2+} > Na^+$
☐ **B** $Li^+ > Na^+ > K^+$
☐ **C** $N^{3-} > O^{2-} > F^-$
☐ **D** $O^{2-} > S^{2-} > Se^{2-}$

(Total for Question 11 = 1 mark)

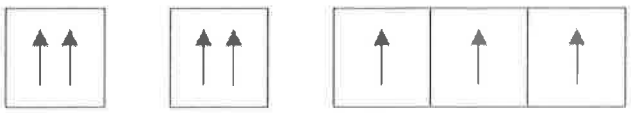
12. A stable ion, M^{3+}, contains 18 electrons.
In which block of the Periodic Table is element **M** found?

- ☐ **A** s
- ☐ **B** p
- ☐ **C** d
- ☐ **D** f

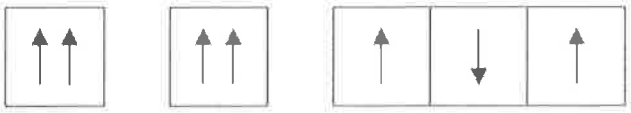
(Total for Question 12 = 1 mark)

13. What is the electronic configuration of a nitrogen atom?

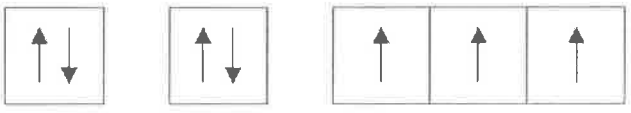
☐ **A**



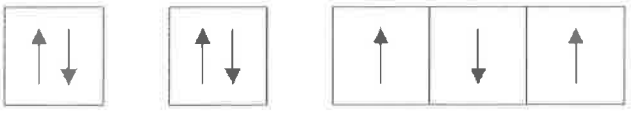
☐ **B**



☐ **C**



☐ **D**



(Total for Question 13 = 1 mark)

14. Some physical properties of five substances are shown. The letters are not element symbols.

Substance	Electrical conductivity			Melting temperature /°C
	Solid	Liquid	Solution in water	
L	poor	good	good	770
M	good	good	reacts	98
N	good	good	insoluble	1083
P	poor	poor	insoluble	113
Q	poor	poor	good	10

(a) Which of these substances could be metals?

(1)

☐ **A** N only
☐ **B** L and M only
☐ **C** M and N only
☐ **D** L, M and N only

(b) Which substance has properties showing that it changes from a molecular structure to ions when it dissolves in water?

(1)

☐ **A** L
☐ **B** M
☐ **C** P
☐ **D** Q

(Total for Question 14 = 2 marks)

15. When carrying out chemical experiments, the hazards and risks must be considered.
For a given chemical

☐ **A** the hazard is fixed but the risk varies
☐ **B** the hazard varies but the risk is fixed
☐ **C** both hazard and risk are fixed
☐ **D** both hazard and risk vary

(Total for Question 15 = 1 mark)

16. All alkanes have the same

- ☐ **A** empirical formula
- ☐ **B** general formula
- ☐ **C** molecular formula
- ☐ **D** structural formula

(Total for Question 16 = 1 mark)

17. A single molecule of decane, $C_{10}H_{22}$, is cracked.
Which of these mixtures could not be formed?

- ☐ **A** pentene and pentane
- ☐ **B** ethene, butene and butane
- ☐ **C** propene, propane and butene
- ☐ **D** hexene and propane

(Total for Question 17 = 1 mark)

18. Which pollutant cannot form when alkane fuels are burned in car engines?

- ☐ **A** hydrogen chloride
- ☐ **B** sulfur dioxide
- ☐ **C** carbon particulates
- ☐ **D** carbon monoxide

(Total for Question 18 = 1 mark)

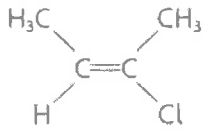
19. An electrophile is a species that

- ☐ **A** can accept a pair of electrons to form a covalent bond.
- ☐ **B** can donate a pair of electrons to form a covalent bond.
- ☐ **C** always has a negative charge.
- ☐ **D** always has a positive charge.

(Total for Question 19 = 1 mark)

20. (a) What is the IUPAC name for the compound with the structure shown?

(1)



☐ **A** cis-2-chlorobut-2-ene
☐ **B** trans-2-chlorobut-2-ene
☐ **C** E-2-chlorobut-2-ene
☐ **D** Z-2-chlorobut-2-ene

(b) What is the total number of sigma bonds in the compound shown above?

(1)

☐ **A** 3
☐ **B** 4
☐ **C** 10
☐ **D** 11

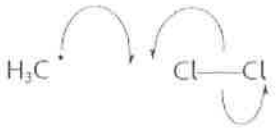
(Total for Question 20 = 2 marks)

21. Which of these occurs in a **propagation** step in the reaction of methane with chlorine?

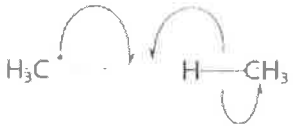
☐ **A**



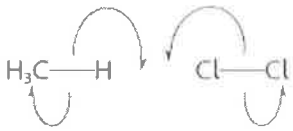
☐ **B**



☐ **C**



☐ **D**



(Total for Question 21 = 1 mark)

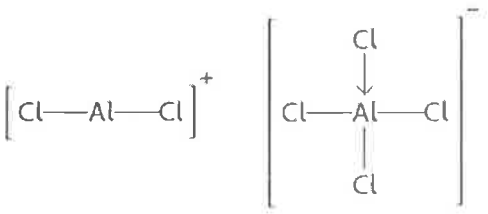
22. Heterolytic fission produces

☐ **A** free radicals only
☐ **B** ions only
☐ **C** free radicals and positive ions only
☐ **D** free radicals and negative ions only

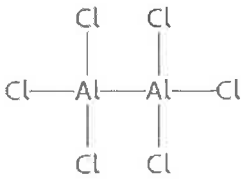
(Total for Question 22 = 1 mark)

23. At 180 °C, aluminium chloride exists as Al_2Cl_6 . What is the structure of Al_2Cl_6 ?

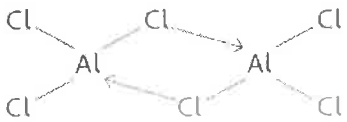
☐ **A**



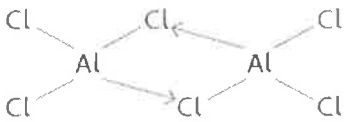
☐ **B**



☐ **C**



☐ **D**



(Total for Question 23 = 1 mark)

TOTAL FOR SECTION A = 25 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

24. This question is about the Group 4 element germanium and some of its compounds.

(a) Naturally-occurring germanium consists of five stable isotopes.

Explain what is meant by the term isotopes.

(2)

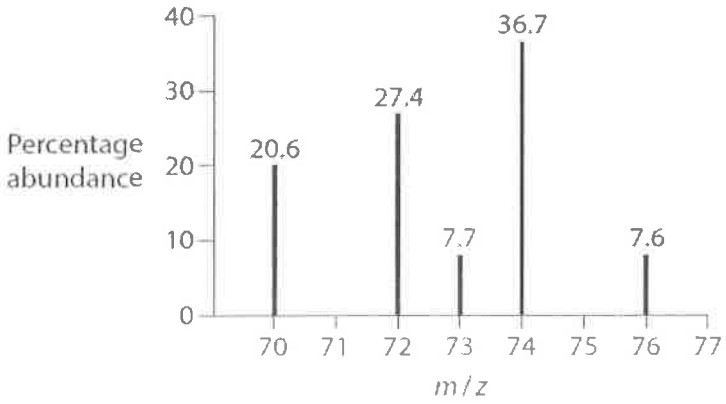
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(b) The mass spectrum of a sample of germanium is shown.



Calculate the relative atomic mass of this sample of germanium.

(2)

(c) Give the electronic configuration of a germanium atom.

(1)

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(d) Germane is a compound with the formula GeH_4.
It can be formed by the reaction shown.

$$Na_2GeO_3 + NaBH_4 + H_2O \rightarrow GeH_4 + 2NaOH + NaBO_2$$

(i) Calculate the atom economy, by mass, for the formation of germane.
Use A_r of Ge = 72.6

(2)

(ii) Germane can donate a proton to ammonia, forming the ion GeH_3^-.

$$NH_3 + GeH_4 \rightarrow NH_4^+ + GeH_3^-$$

Draw a dot-and-cross diagram of the ion GeH_3^-. Show the outer electrons only.

(2)

(iii) Use your answer to (d)(ii) and electron-pair repulsion theory to predict the name and explain the shape and bond angle of the ion GeH_3^-.

(4)

Name of the shape .....

Bond angle .....

Explanation .....

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(iv) Germane is toxic and the maximum permitted concentration is $0.640\,mg.m^{-3}$ in air. Calculate the maximum number of germane molecules permitted in a laboratory with a volume of $231m^3$.
[Avogadro constant (L) = $6.02 \times 10^{23} mol^{-1}$]

(4)

(e) A halide of germanium, GeX_4, reacts with water as shown.

$$GeX_4 + 2H_2O \rightarrow GeO_2 + 4HX$$

1.50 g of GeX_4 was added to excess water. The insoluble GeO_2 was removed by filtration. The solution of hydrogen halide formed was then added to excess magnesium carbonate, forming $335.5\,cm^3$ of carbon dioxide at room temperature and pressure (r.t.p.).

$$MgCO_3 + 2HX \rightarrow MgX_2 + CO_2 + H_2O$$

[Molar volume of a gas at r.t.p. = $24000\,cm^3\,mol^{-1}$]

(i) Calculate the number of moles of carbon dioxide formed.

(1)

(ii) Deduce the number of moles of HX formed when GeX_4 reacted with the excess water.

(1)

(iii) Deduce the number of moles of GeX_4 that reacted with the excess water.

(1)

(iv) Calculate the molar mass of GeX_4 and hence identify X.

(2)

(Total for Question 24 = 22 marks)

25. This question is about some metals and their compounds.

a) Aluminium is an abundant metal with many uses.

(i) The first four ionisation energies of aluminium are shown.

Ionisation number	Energy/ $kJmol^{-1}$
1	578
2	1820
3	2750
4	11600

Explain how this information shows that aluminium is in Group 3 of the Periodic Table.

(2)

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(ii) Give two possible reasons why aluminium is used for overhead power cables.

(2)

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(iii) New uses for waste aluminium cans are being investigated. One possible use is to make nanoparticle alloys to produce hydrogen for fuel.
Aluminium nanoparticles react with water to produce aluminium oxide and hydrogen.

$$2Al + 3H_2O \rightarrow 3H_2 + Al_2O_3$$

Give **two** possible reasons for producing hydrogen from aluminium rather than from fossil fuels.

(2)

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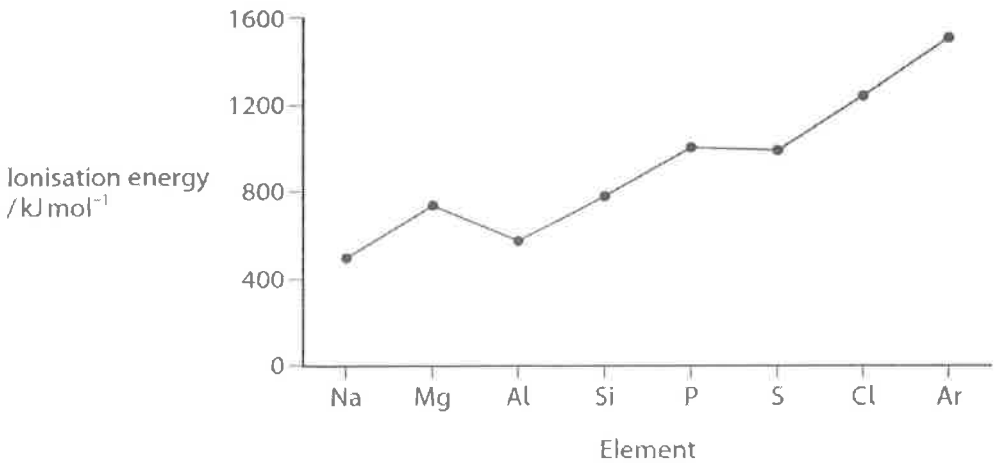
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(iv) The graph shows the first ionisation energies for the elements in Period 3.



Explain why the first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

(2)

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(b) Barium is a group 2 metal.
An acidified aqueous solution of its compound barium chloride, $BaCl_2$, is used to test for sulfate ions.

(i) Draw a dot-and-cross diagram for barium chloride.
Show the outer electrons only.

(2)

(ii) The barium chloride solution is acidified to prevent carbonate ions giving a false positive result. Write the ionic equation for the reaction of hydrochloric acid with carbonate ions. State symbols are not required.

(1)

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*(c) In terms of bonding and structure, compare and contrast the electrical conductivity of aluminum metal and solid barium chloride.

(5)

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(Total for Question 25 = 16 marks)

26. Alkanes and alkenes are obtained from crude oil.

(a) Describe how a sample of octane can be obtained from a mixture of alkanes.

(2)

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(b) The skeletal formula of octane is



Draw four structural isomers of octane in the boxes.

(4)

Isomer 1	Isomer 2
Isomer 3	Isomer 4

(c) Petrol used in cars has a high proportion of the alkane iso-octane.
Iso-octane can be formed by heating octane to 400 °C in the presence of a catalyst.



octane iso-octane

(i) Give the IUPAC name for iso-octane.

(1)

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(ii) Name the industrial process used to convert octane into iso-octane.

(1)

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(iii) Give a reason why petrol needs a high proportion of iso-octane.

(1)

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(iv) Another way to produce iso-octane is by reacting iso-butane with 2-methylpropene.



iso-butane 2-methylpropene iso-octane

Draw the **skeletal** formulae of 2 isomers of 2-methylpropene.
Include only **one** isomer that does not decolorise bromine water.

(2)

(d) Octane reacts with bromine in the presence of ultraviolet radiation to form a mixture of bromoalkanes.

(i) Draw the initiation step of this reaction, using curly half-arrows.

(2)

(ii) Write equations for **two** propagation steps to show how $C_8H_{17}Br$ is formed. Curly arrows are not required.

(2)

(iii) Give the **molecular** formula of an alkane formed in a termination step in this reaction.

(1)

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(iv) Calculate the percentage by mass of bromine in the heaviest molecule containing eight carbon atoms that could form when octane reacts with a **large excess** of bromine.

(3)

(e) Another component of petrol, compound **X**, contains 92.3 % carbon and 7.7 % hydrogen by mass.

(i) Calculate the empirical formula of compound **X**. You must show all your working.

(2)

(ii) A sample of compound **X** has a mass of 0.267 g and vaporises at 85.0 °C and 104 kPa to produce a gaseous sample with a volume of $98.0 cm^3$.

Calculate the molar mass of compound **X**.

You must show all your working.

[pV = nRT $R = 8.31 J mol^{-1} K^{-1}$]

(4)

(iii) Deduce the molecular formula of compound **X**, using your answers to (e)(i) and (e)(ii).

(1)

(Total for Question 26 = 26 marks)

27. This question is about alkenes.

Alkenes contain a carbon to carbon double bond that consists of a σ bond and a π bond.

(a) Complete the diagram to show the areas of electron density for each bond.

Label the σ bond and the π bond.

(2)

C C

(b) Isoprene is used to make synthetic rubber. The skeletal formula for isoprene is shown.



(i) State why isoprene does **not** have geometric isomers.

(1)

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(ii) A related molecule does show geometric isomerism.



Draw the geometric isomer of this molecule.

(1)

(iii) Give a reason why a double bond may result in geometric isomerism.

(1)

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(c) Ethene and chlorine react to form 1,2-dichloroethane.

(i) Draw the mechanism for the reaction between ethene and chlorine to form 1,2-dichloroethane. Include curly arrows, and relevant lone pairs and dipoles.

(4)

(ii) One hazard symbol for 1,2-dichloroethane is shown.



By identifying this hazard, give **one** way of minimising the risk when working with 1,2-dichloroethane in a laboratory.
Assume the use of safety goggles and a laboratory coat.

(2)

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(Total for Question 27 = 11 marks)
TOTAL FOR SECTION B = 75 MARKS
TOTAL FOR PAPER = 100 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

SECTION A

Answer ALL the questions in this section.
You should aim to spend no more than 25 minutes on this section.
For each question, select one answer from A to D and put a cross in the box.
If you change your mind, put a line through ☒ the box and then mark your new answer with a cross. ☒

1. How many molecules are there in 44.0 g of carbon monoxide?
Avogadro constant $L = 6.02 \times 10^{23}\ mol^{-1}$

- ☐ **A** 3.83×10^{23}
- ☐ **B** 6.02×10^{23}
- ☒ **C** 9.46×10^{23}
- ☐ **D** 1.89×10^{24}

(Total for Question 1 = 1 mark)

2. A compound has $M_r = 84$ and its composition by mass is 71.4 % carbon, 9.6 % hydrogen and 19.0 % oxygen.
What is the molecular formula of this compound?

- ☐ **A** $C_4H_3O_2$
- ☐ **B** $C_4H_4O_2$
- ☒ **C** C_5H_8O
- ☐ **D** $C_6H_{10}O$

(Total for Question 2 = 1 mark)

3. Which of these compounds has the same empirical and molecular formulae?

- ☐ **A** C_2H_4
- ☒ **B** C_3H_8
- ☐ **C** C_4H_{10}
- ☐ **D** C_5H_{10}

(Total for Question 3 = 1 mark)

4. The equation for the complete combustion of hexane is shown.

$$C_6H_{14} + 9½\ O_2 \rightarrow 6CO_2 + 7H_2O$$

How many molecules of carbon dioxide are formed when $2 \times 10^{-3} mol$ of hexane undergoes complete combustion?
[Avogadro constant $L = 6.02 \times 10^{23} mol^{-1}$]

- ☐ **A** 1.20×10^{21}
- ☒ **B** 7.22×10^{21}
- ☐ **C** 8.43×10^{21}
- ☐ **D** 3.18×10^{23}

(Total for Question 4 = 1 mark)

5. Which of these solutions contains the greatest number of ions?

- ☐ **A** $20.0 cm^3$ of $0.5 mol\, dm^{-3}$ KCl
- ☒ **B** $0.40 dm^3$ of $0.03 mol\, dm^{-3}$ KCl
- ☐ **C** $10.0 cm^3$ of $0.6 mol\, dm^{-3}$ $CaCl_2$
- ☐ **D** $0.15 dm^3$ of $0.04 mol\, dm^{-3}$ $CaCl_2$

(Total for Question 5 = 1 mark)

6. What is the ionic equation for the reaction between aqueous solutions of barium nitrate and sodium sulfate?

- ☐ **A** $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(s)$
- ☐ **B** $2Ba^+(aq) + SO_4^{2-}(aq) \rightarrow Ba_2SO_4(s)$
- ☐ **C** $Na^{2+}(aq) + 2NO_3^-(aq) \rightarrow Na(NO_3)_2(s)$
- ☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 6 = 1 mark)

7. The atomic number of the element scandium is 21 and the mass number of its only isotope is 45.
In a mass spectrometer, scandium forms Sc^+ and Sc^{2+} ions.
What is the m/z value for the mass spectrum peak due to the Sc^{2+} ions?

- ☒ **A** 22.5
- ☐ **B** 33.0
- ☐ **C** 45.0
- ☐ **D** 90.0

(Total for Question 7 = 1 mark)

8. Which equation represents the **second** ionisation energy of chlorine?

☐ **A** $Cl^-(g) + e^- \rightarrow Cl^{2-}(g)$
☐ **B** $Cl(g) + 2e^- \rightarrow Cl^{2-}(g)$
☐ **C** $2Cl(g) \rightarrow 2Cl^+(g) + 2e^-$
☒ **D** $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

(1) ✓

(Total for Question 8 = 1 mark)

9. A mass of 0.23 g of sodium was added to $350 cm^3$ water to form hydrogen and a solution of sodium hydroxide.

$$Na(s) + H_2O(l) \rightarrow NaOH(aq) + \tfrac{1}{2}H_2(g)$$

What is the maximum volume, in cm^3, of hydrogen which could be formed, measured at r.t.p.? [Molar volume of a gas at r.t.p. = $24 dm^3 mol^{-1}$]

(1) ✓

☒ **A** 120
☐ **B** 240
☐ **C** 480
☐ **D** 2800

(Total for Question 9 = 1 mark)

10. Ions with the same electronic configuration are said to be isoelectronic.
Which of the following compounds is made up of isoelectronic ions?

☐ **A** CaO
☐ **B** $CaBr_2$
☒ **C** Na_2O
☐ **D** LiF

(1) ✓

(Total for Question 10 = 1 mark)

11. In which series are the ions in order of **decreasing** ionic radius?

☐ **A** $Al^{3+} > Mg^{2+} > Na^+$
☐ **B** $Li^+ > Na^+ > K^+$
☒ **C** $N^{3-} > O^{2-} > F^-$
☐ **D** $O^{2-} > S^{2-} > Se^{2-}$

(1) ✓

(Total for Question 11 = 1 mark)

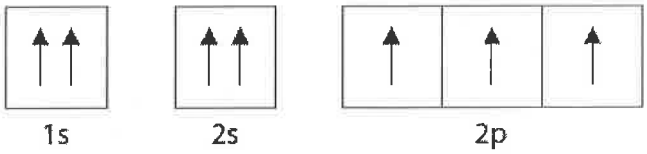
12. A stable ion, M^{3+}, contains 18 electrons.
In which block of the Periodic Table is element **M** found?

- ☐ A s
- ☒ B p
- ☐ C d
- ☐ D f

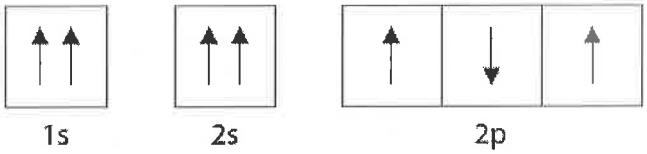
(Total for Question 12 = 1 mark)

13. What is the electronic configuration of a nitrogen atom?

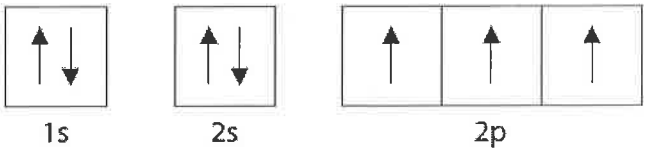
☐ A



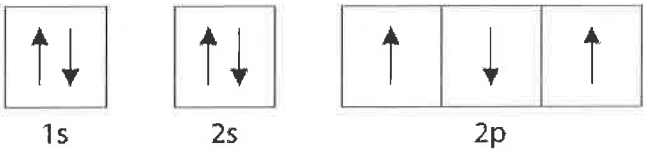
☐ B



☒ C



☐ D



(Total for Question 13 = 1 mark)

14. Some physical properties of five substances are shown. The letters are not element symbols.

Substance	Electrical conductivity			Melting temperature /°C
	Solid	Liquid	Solution in water	
L	poor	good	good	770
M	good	good	reacts	98
N	good	good	insoluble	1083
P	poor	poor	insoluble	113
Q	poor	poor	good	10

(a) Which of these substances could be metals?

(1)

- ☐ **A** N only
- ☐ **B** L and M only
- ☒ **C** M and N only
- ☐ **D** L, M and N only

(b) Which substance has properties showing that it changes from a molecular structure to ions when it dissolves in water?

(1)

- ☐ **A** L
- ☐ **B** M
- ☐ **C** P
- ☒ **D** Q

(Total for Question 14 = 2 marks)

15. When carrying out chemical experiments, the hazards and risks must be considered. For a given chemical

- ☒ **A** the hazard is fixed but the risk varies
- ☐ **B** the hazard varies but the risk is fixed
- ☐ **C** both hazard and risk are fixed
- ☐ **D** both hazard and risk vary

(Total for Question 15 = 1 mark)

16. All alkanes have the same

- ☐ **A** empirical formula
- ☒ **B** general formula
- ☐ **C** molecular formula
- ☐ **D** structural formula

(Total for Question 16 = 1 mark)

17. A single molecule of decane, $C_{10}H_{22}$, is cracked.
Which of these mixtures could not be formed?

- ☐ **A** pentene and pentane
- ☐ **B** ethene, butene and butane
- ☐ **C** propene, propane and butene
- ☒ **D** hexene and propane

(Total for Question 17 = 1 mark)

18. Which pollutant cannot form when alkane fuels are burned in car engines?

- ☒ **A** hydrogen chloride
- ☐ **B** sulfur dioxide
- ☐ **C** carbon particulates
- ☐ **D** carbon monoxide

(Total for Question 18 = 1 mark)

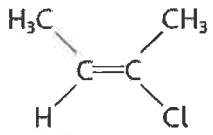
19. An electrophile is a species that

- ☒ **A** can accept a pair of electrons to form a covalent bond.
- ☐ **B** can donate a pair of electrons to form a covalent bond.
- ☐ **C** always has a negative charge.
- ☐ **D** always has a positive charge.

(Total for Question 19 = 1 mark)

20. (a) What is the IUPAC name for the compound with the structure shown?

(1)



- ☐ **A** cis-2-chlorobut-2-ene
- ☐ **B** trans-2-chlorobut-2-ene
- ☒ **C** E-2-chlorobut-2-ene
- ☐ **D** Z-2-chlorobut-2-ene

(b) What is the total number of sigma bonds in the compound shown above?

(1)

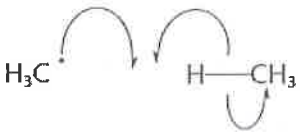
- ☐ **A** 3
- ☐ **B** 4
- ☐ **C** 10
- ☒ **D** 11

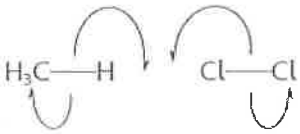
(Total for Question 20 = 2 marks)

21. Which of these occurs in a **propagation** step in the reaction of methane with chlorine?

- ☐ **A** 

- ☒ **B** 

- ☐ **C** 

- ☐ **D** 

(Total for Question 21 = 1 mark)

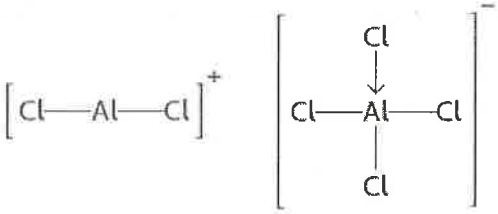
22. Heterolytic fission produces

- ☐ **A** free radicals only
- ☒ **B** ions only
- ☐ **C** free radicals and positive ions only
- ☐ **D** free radicals and negative ions only

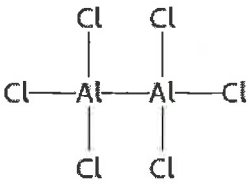
(Total for Question 22 = 1 mark)

23. At 180 °C, aluminium chloride exists as Al_2Cl_6 . What is the structure of Al_2Cl_6 ?

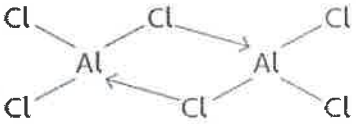
☐ **A**



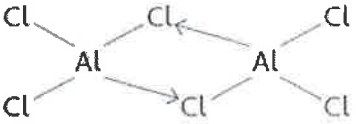
☐ **B**



☒ **C**



☐ **D**



(Total for Question 23 = 1 mark)

TOTAL FOR SECTION A = 25 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

24. This question is about the Group 4 element germanium and some of its compounds.

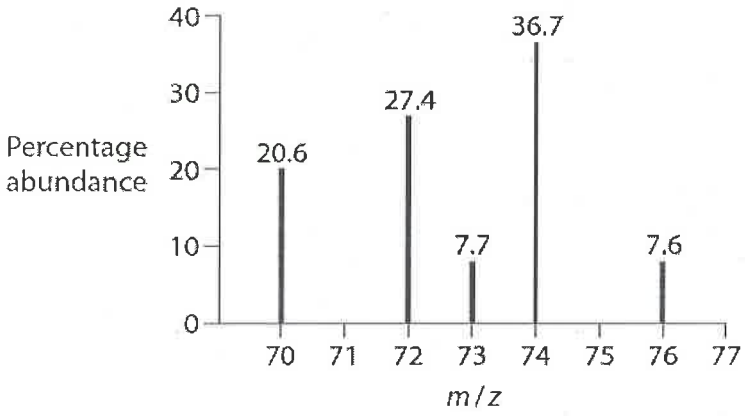
(a) Naturally-occurring germanium consists of five stable isotopes.

Explain what is meant by the term isotopes.

(2)

Isotopes are atoms of the same element with the same number of protons but different number of neutrons. ✓✓ (2)

(b) The mass spectrum of a sample of germanium is shown.



Calculate the relative atomic mass of this sample of germanium.

(2)

$$R.A.M = \frac{70 \times 20.6 + 72 \times 27.4 + 73 \times 7.7 + 74 \times 36.7 + 76 \times 7.6}{100}$$ ✓ (1)

$R.A.M = 72.70$ ✓ (1)

(c) Give the electronic configuration of a germanium atom.

(1)

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^2$ ✓ (1)

(d) Germane is a compound with the formula GeH_4.
It can be formed by the reaction shown.

$$Na_2GeO_3 + NaBH_4 + H_2O \rightarrow GeH_4 + 2NaOH + NaBO_2$$

(i) Calculate the atom economy, by mass, for the formation of germane.
Use A_r of Ge = 72.6

(2)

$$\% \text{ atom economy} = \frac{M_r(GeH_4)}{\Sigma M_r(\text{reactants})} \times 100 \quad (1)$$

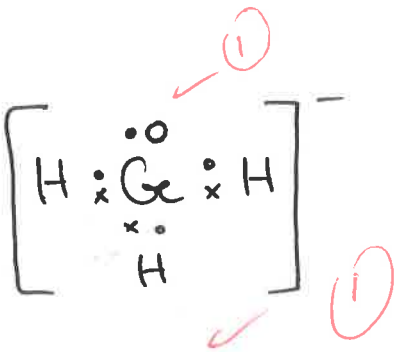
$$= \frac{76.6}{222.4} \times 100 = 34.4\% \quad (1)$$

(ii) Germane can donate a proton to ammonia, forming the ion GeH_3^-.

$$NH_3 + GeH_4 \rightarrow NH_4^+ + GeH_3^-$$

Draw a dot-and-cross diagram of the ion GeH_3^-. Show the outer electrons only.

(2)



(1) (1)

(iii) Use your answer to (d)(ii) and electron-pair repulsion theory to predict the name and explain the shape and bond angle of the ion GeH_3^-.

(4)

Name of the shape ..... trigonal pyramidal ..... (1)

Bond angle ..... 107.4° ..... (1)

Explanation ..... Around the central atom Ge, there (1) are 3 bonding pairs and one lone pair. These pairs of e^- arrange themselves, such to minimise repulsion. And according to the EPR theory, the repulsion (1) between lone pair and bonding pair is greater than that between 2 bonding pairs.

(iv) Germane is toxic and the maximum permitted concentration is $0.640 mg.m^{-3}$ in air. Calculate the maximum number of germane molecules permitted in a laboratory with a volume of $231 m^3$.

[Avogadro constant (L) = $6.02 \times 10^{23} mol^{-1}$]

(4)

$m_{GeH_4(max)} = 0.640 \times 231 = 147.84$ mg (1) (1)

$\Rightarrow n_{GeH_4(max)} = \frac{147.84 \times 10^{-3}}{76.6} = 1.93 \times 10^{-3}$ mol (1)

$\Rightarrow$ number of molecules $= 1.93 \times 10^{-3} \times 6.02 \times 10^{23}$

$= 1.16 \times 10^{21}$ molecules. (1)

(e) A halide of germanium, GeX_4, reacts with water as shown.

$$GeX_4 + 2H_2O \rightarrow GeO_2 + 4HX$$

1.50 g of GeX_4 was added to excess water. The insoluble GeO_2 was removed by filtration. The solution of hydrogen halide formed was then added to excess magnesium carbonate, forming $335.5\,cm^3$ of carbon dioxide at room temperature and pressure (r.t.p.).

$$MgCO_3 + 2HX \rightarrow MgX_2 + CO_2 + H_2O$$

[Molar volume of a gas at r.t.p. = $24000\,cm^3\,mol^{-1}$]

(i) Calculate the number of moles of carbon dioxide formed.

(1)

$n_{CO_2} = \frac{335.5}{24000} = 0.014$ mol ✓ (1)

(ii) Deduce the number of moles of HX formed when GeX_4 reacted with the excess water.

(1)

HX : CO_2

2 : 1 => $n_{HX} = 0.028$ mol ✓ (1)

(iii) Deduce the number of moles of GeX_4 that reacted with the excess water.

(1)

GeX_4 : HX

1 : 4 => $n_{GeX_4} = \frac{n_{HX}}{4} = 0.007$ mol ✓ (1)

(iv) Calculate the molar mass of GeX_4 and hence identify X.

(2)

$M_{GeX_4} = \frac{1.50}{0.007} = 214.29$ ✓ (1)

=> $A_r(X) = \frac{214.29 - 72.6}{4} = 35.4$ ✓

=> X is Cl ✓ (1)

(Total for Question 24 = 22 marks)

25. This question is about some metals and their compounds.

a) Aluminium is an abundant metal with many uses.

(i) The first four ionisation energies of aluminium are shown.

Ionisation number	Energy/ $kJmol^{-1}$
1	578
2	1820
3	2750
4	11600

Explain how this information shows that aluminium is in Group 3 of the Periodic Table. (2)

The non-linear increase of I.E values compared ~~corresponds~~ to other increases, corresponds to the removal of an e^- from an inner energy level ✓(1) In the above list, this jumps is @ the 4th I.E, hence it's in group III ✓(1)

(ii) Give two possible reasons why aluminium is used for overhead power cables. (2)

- Good conductor of electricity ✓(1)
- It's ductile ✓(1)

(iii) New uses for waste aluminium cans are being investigated. One possible use is to make nanoparticle alloys to produce hydrogen for fuel.
Aluminium nanoparticles react with water to produce aluminium oxide and hydrogen.

$$2Al + 3H_2O \rightarrow 3H_2 + Al_2O_3$$

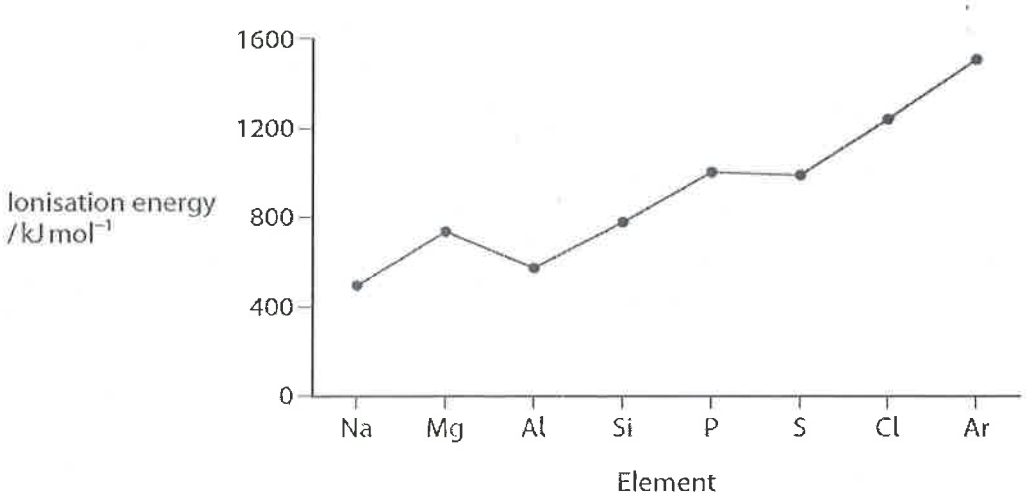
Give **two** possible reasons for producing hydrogen from aluminium rather than from fossil fuels.

(2)

Less greenhouse are emitted compared to combustion of fossil fuels. ✓ (1)

Aluminium can be recycled ✓ (1)

(iv) The graph shows the first ionisation energies for the elements in Period 3.



Explain why the first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

(2)

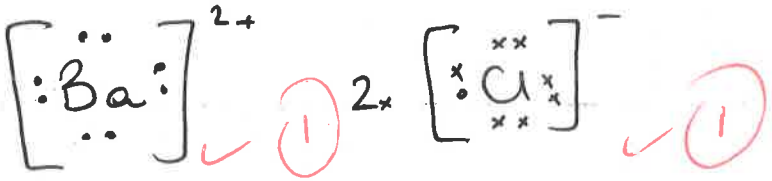
Aluminium's 1st e⁻ is being removed from 3p sublevel, unlike that of Mg which is removed from 3s. ✓ The increase in distance (although slight) and shielding effect overcome the increase in nuclear charge ✓ (1)

(1)

(b) Barium is a group 2 metal.
An acidified aqueous solution of its compound barium chloride, $BaCl_2$, is used to test for sulfate ions.

(i) Draw a dot-and-cross diagram for barium chloride.
Show the outer electrons only.

(2)



(ii) The barium chloride solution is acidified to prevent carbonate ions giving a false positive result. Write the ionic equation for the reaction of hydrochloric acid with carbonate ions. State symbols are not required.

(1)

$2H^+ + CO_3^{2-} \longrightarrow H_2O + CO_2$

*(c) In terms of bonding and structure, compare and contrast the electrical conductivity of aluminum metal and solid barium chloride.

(5)

In aluminium, the sea of delocalised e^- surrounding the array of cations allows the metal to conduct electricity in solid and in molten state. while in barium chloride, the barium ions and the chloride ions are in fixed position, at the vertices of the cubic structure, in solid state. Hence, barium chloride doesn't conduct electricity in solid state but does as aqueous solution.

for a coherant answer.

(Total for Question 25 = 16 marks)

26. Alkanes and alkenes are obtained from crude oil.

(a) Describe how a sample of octane can be obtained from a mixture of alkanes.

(2)

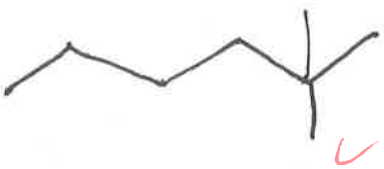
The mixture is heated, until the (1)
point of boiling, in a distillation (fractional)
set up. Each component is collected
at its Tb. (1)

(b) The skeletal formula of octane is

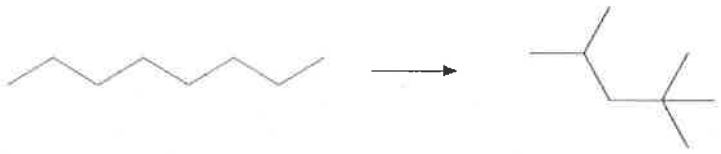


Draw four structural isomers of octane in the boxes.

(4)

Isomer 1	Isomer 2
 (1)	 (1)
Isomer 3	**Isomer 4**
 (1)	 (1)

(c) Petrol used in cars has a high proportion of the alkane iso-octane.
Iso-octane can be formed by heating octane to 400 °C in the presence of a catalyst.



octane iso-octane

(i) Give the IUPAC name for iso-octane.

2,2,4 - trimethylpentane ✓1 (1)

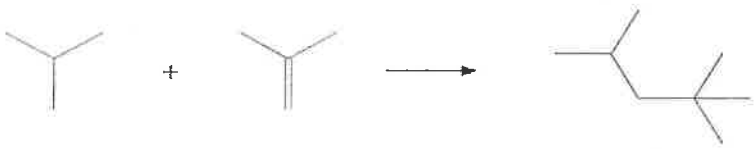
(ii) Name the industrial process used to convert octane into iso-octane.

Reforming ✓1 (1)

(iii) Give a reason why petrol needs a high proportion of iso-octane.

To minimise / lessen the knocking of the engine. ✓1 (1)

(iv) Another way to produce iso-octane is by reacting iso-butane with 2-methylpropene.



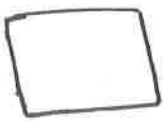
iso-butane 2-methylpropene iso-octane

Draw the **skeletal** formulae of 2 isomers of 2-methylpropene.
Include only **one** isomer that does not decolorise bromine water.

(2)



✓1



✓1

(d) Octane reacts with bromine in the presence of ultraviolet radiation to form a mixture of bromoalkanes.

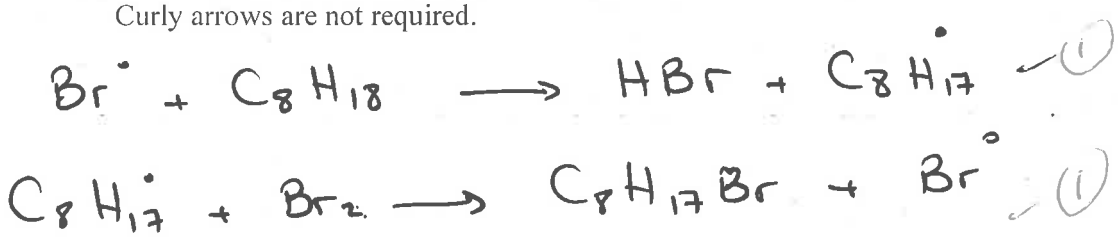
(i) Draw the initiation step of this reaction, using curly half-arrows.

(2)



(ii) Write equations for **two** propagation steps to show how $C_8H_{17}Br$ is formed. Curly arrows are not required.

(2)



(iii) Give the **molecular** formula of an alkane formed in a termination step in this reaction.

(1)

$C_{16}H_{34}$ ✓

(iv) Calculate the percentage by mass of bromine in the heaviest molecule containing eight carbon atoms that could form when octane reacts with a **large excess** of bromine.

(3)

In large excess the following compound forms : C_8Br_{18}

$$\%\,Br_{(by\ mass)} = \frac{18 \times 79.9}{18 \times 79.9 + 8 \times 12} \times 100$$

$$= \frac{1438.2}{1534.2} \times 100 = 93.7\%$$

(e) Another component of petrol, compound **X**, contains 92.3 % carbon and 7.7 % hydrogen by mass.

(i) Calculate the empirical formula of compound **X**. You must show all your working.

(2)

in 100g of X :

	C	H
	$\frac{92.3}{12}$	$\frac{7.7}{1}$
	$\frac{7.692}{7.692}$	$\frac{7.7}{7.692}$
	1	1

(1)

$\Rightarrow$ $(CH)_x$ (1)

(ii) A sample of compound **X** has a mass of 0.267 g and vaporises at 85.0 °C and 104 kPa to produce a gaseous sample with a volume of $98.0\,cm^3$.

Calculate the molar mass of compound **X**.

You must show all your working.

[pV = nRT $R = 8.31\,J\,mol^{-1}\,K^{-1}$]

(4)

$T = 273 + 85 = 358\,K$

$P = 104 \times 10^3\ Pa$

$V = 98 \times 10^{-6}\ m^3$ (2)

$n = \frac{104 \times 10^3 \times 98 \times 10^{-6}}{8.31 \times 358} = 3.43 \times 10^{-3}\ mol$ (1)

$\Rightarrow M = \frac{0.267}{3.43 \times 10^{-3}} = 78\ g.mol^{-1}$ (1)

(iii) Deduce the molecular formula of compound **X**, using your answers to (e)(i) and (e)(ii).

(1)

$x = \frac{78}{13} = 6 \Rightarrow$ M.F of X is C_6H_6. (1)

(Total for Question 26 = 26 marks)

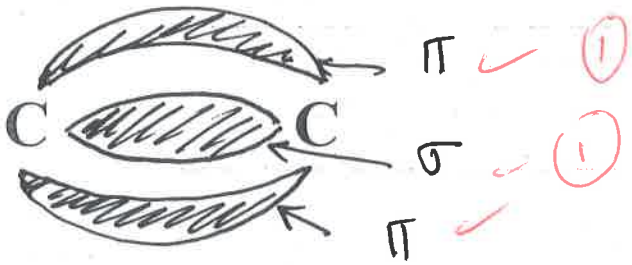
27. This question is about alkenes.

Alkenes contain a carbon to carbon double bond that consists of a σ bond and a π bond.

(a) Complete the diagram to show the areas of electron density for each bond.

Label the σ bond and the π bond.

(2)



(b) Isoprene is used to make synthetic rubber. The skeletal formula for isoprene is shown.



(i) State why isoprene does **not** have geometric isomers.

(1)

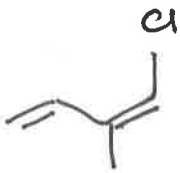
Identical atoms are bonded to the C atom at the C=C

(ii) A related molecule does show geometric isomerism.



Draw the geometric isomer of this molecule.

(1)



(iii) Give a reason why a double bond may result in geometric isomerism.

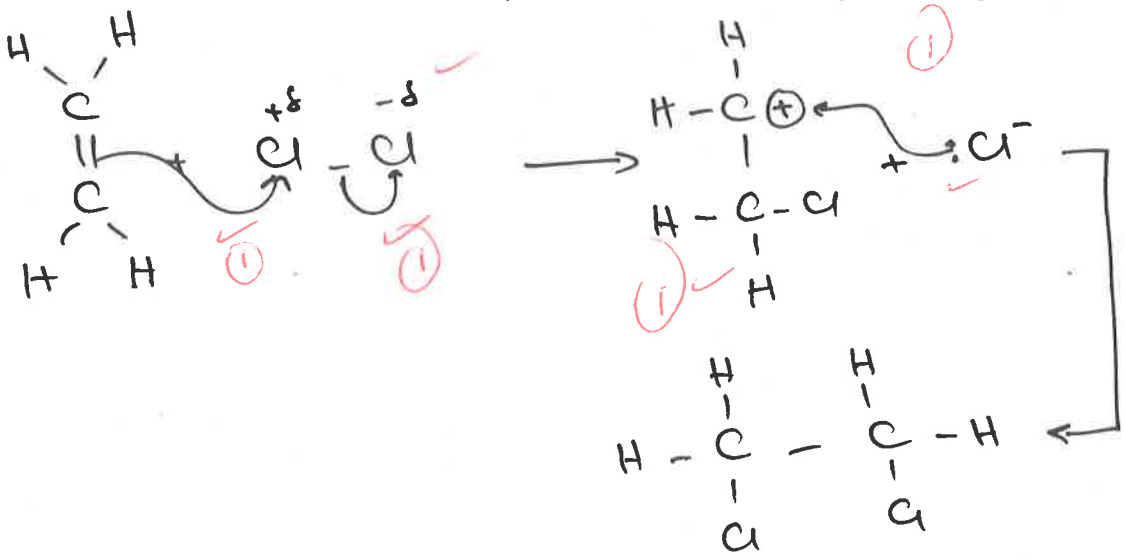
(1)

There exists a restricted rotation around the π bond. (1)

(c) Ethene and chlorine react to form 1,2-dichloroethane.

(i) Draw the mechanism for the reaction between ethene and chlorine to form 1,2-dichloroethane. Include curly arrows, and relevant lone pairs and dipoles.

(4)



(ii) One hazard symbol for 1,2-dichloroethane is shown.



By identifying this hazard, give **one** way of minimising the risk when working with 1,2-dichloroethane in a laboratory.
Assume the use of safety goggles and a laboratory coat.

(2)

1,2-dichloroethane is flammable (1)
It should be kept away from any source of flame. (1)

(Total for Question 27 = 11 marks)
TOTAL FOR SECTION B = 75 MARKS
TOTAL FOR PAPER = 100 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series