This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 02

08DEC2023

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

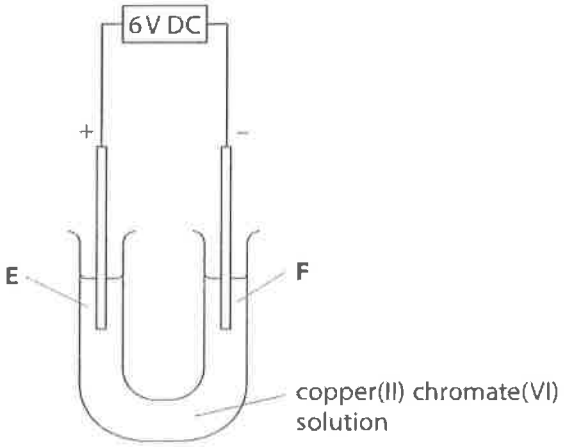
Answer ALL the questions in this section.
You should aim to spend no more than 20 minutes on this section.
For each question, select one answer from A to D and put a cross in the box.
If you change your mind, put a line through ☒ the box and then mark your new answer with a cross. ☒

1. Ionic bonding is the strong electrostatic attraction between

☒ **A** anions and cations
☒ **B** atoms and delocalised electrons
☒ **C** cations and delocalised electrons
☒ **D** two nuclei and a shared pair of electrons

(Total for Question 1 = 1mark)

2. An aqueous solution of green copper(II) chromate(VI) was electrolysed using the apparatus shown in the diagram.



The colours of the solutions in regions **E** and **F** after the electrolysis has occurred are

☒ **A** blue in region **E** and yellow in region **F**
☒ **B** yellow in region **E** and blue in region **F**
☒ **C** green in region **E** and colourless in region **F**
☒ **D** colourless in region **E** and green in region **F**

(Total for Question 2 = 1mark)

3. Some ionic radii are given in the table.

Ion	Ionic radius/nm
Na^+	0.102
Mg^{2+}	0.072
Cl^-	0.180
Br^-	0.195

The formula of the compound, formed from the ions in the table, that has the strongest ionic bonding is

☒ **A** NaCl
☒ **B** $MgCl_2$
☒ **C** NaBr
☐ **D** $MgBr_2$

(Total for Question 3 = 1mark)

4. The names of four substances are given.

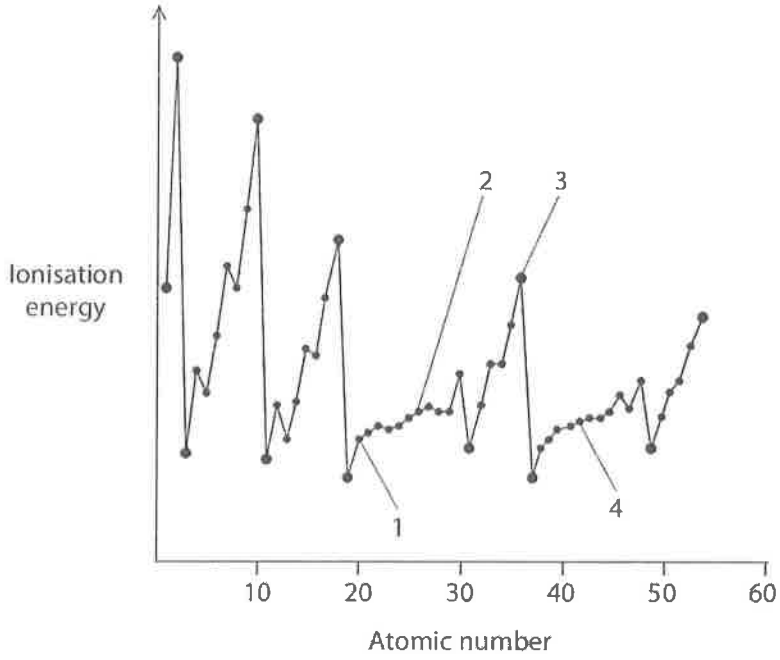
Substance	Name
P	copper
Q	iodine
R	silicon(IV) dioxide
S	sodium chloride

Which of these substances has a high melting temperature, and conducts electricity when solid and when molten?

☐ **A** Substance P
☐ **B** Substance Q
☒ **C** Substance R
☐ **D** Substance S

(Total for Question 4 = 1mark)

5. Which of the labels 1–4 identifies a p-block element in Period 4?



☒ **A** 1
☒ **B** 2
☒ **C** 3
☐ **D** 4

(Total for Question 5 = 1mark)

6. What is the stable electronic configuration of a copper atom?

☒ **A** [Ar] $4s^1\ 3d^{10}$
☐ **B** [Ar] $4s^2\ 3d^9$
☐ **C** [Ar] $4s^2\ 4p^1\ 3d^8$
☐ **D** [Ar] $4s^2\ 4p^2\ 3d^7$

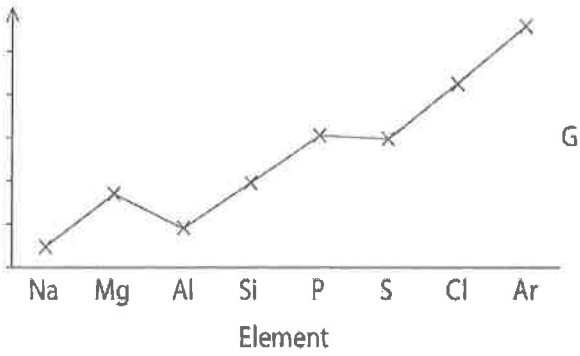
(Total for Question 6 = 1mark)

7. Which is the most likely sequence of values, in kJ mol^{-1}, for the first four ionisation energies of barium?

☒ **A** 1000 2251 3361 4564
☒ **B** 496 4563 6913 9544
☒ **C** 503 965 3458 4530
☐ **D** 578 1817 2745 11 578

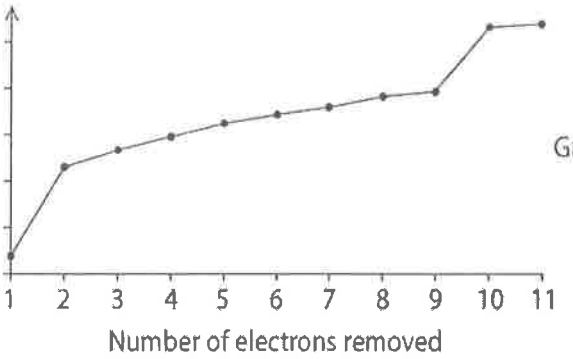
(Total for Question 7 = 1 mark)

8. Graph 1 shows the variation in first ionisation energy with increasing atomic number.



Graph 1

Graph 2 shows the variation in successive ionisation energies for sodium.



Graph 2

(a) What quantities were plotted on the y-axes to produce these graphs?

(1)

	Graph 1 First ionisation energy of successive elements	Graph 2 Successive ionisation energies of sodium
☒ A	actual value	log of value
☒ B	log of value	log of value
☒ C	log of value	actual value
☒ D	actual value	actual value

(b) What is the number of **quantum** shells in a sodium atom suggested by Graph 2?

(1)

☐ **A** Two
☐ **B** Three
☐ **C** Four
☐ **D** Six

(Total for Question 8 = 2 marks)

9. What is the shape of the ICl_4^- ion?

- ☒ **A** octahedral
- ☒ **B** square planar
- ☒ **C** tetrahedral
- ☒ **D** trigonal bipyramidal

(Total for Question 9 = 1mark)

10. Which describes the polarity of the P—Cl bond and the polarity of the phosphorus(III) chloride, PCl_3, molecule?

		Polarity of the P—Cl bond	Polarity of molecule
☒	**A**	Non-polar	Non-polar
☒	**B**	Non-polar	Polar
☒	**C**	Polar	non-polar
☒	**D**	polar	polar

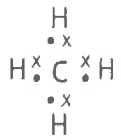
(Total for Question 10 = 1mark)

11. The O–H bond in water is polar because, when compared with the hydrogen atom, the oxygen atom has

- ☒ **A** a higher mass number
- ☒ **B** a larger atomic radius
- ☒ **C** greater electronegativity
- ☒ **D** more electrons

(Total for Question 11 = 1mark)

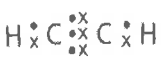
12. Four dot-and-cross electron diagrams are shown.



W



X



Y



Z

Which diagrams are correct?

- ☒ **A** W, X, Y and Z only
- ☒ **B** W, Y and Z only
- ☒ **C** W and Z only
- ☒ **D** X and Z only

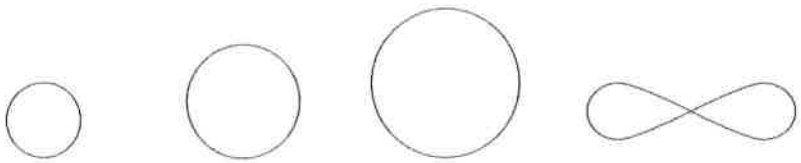
(Total for Question 12 = 1 mark)

13. Which molecule contains the greatest number of π bonds?

- ☒ **A** CO_2
- ☒ **B** C_2H_4
- ☒ **C** C_2H_6
- ☒ **D** C_4H_8

(Total for Question 13 = 1 mark)

14. The diagrams show the shape and relative size of four of the atomic orbitals occupied in a magnesium atom.



E **F** **G** **H**

Which diagram shows a 2s orbital?

- ☒ **A** E
- ☐ **B** F
- ☐ **C** G
- ☐ **D** H

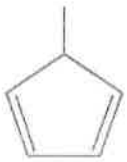
(Total for Question 14 = 1 mark)

15. The number of structural isomers with formula C_6H_{14} is

☒ **A** 3
☒ **B** 4
☒ **C** 5
☒ **D** 6

(Total for Question 15 = 1 mark)

16. A cyclic hydrocarbon has the structure shown.



(i) How many pi (π) and sigma (σ) bonds are present in the molecule?

(1)

		pi (π) bonds	sigma (σ) bonds
☒	**A**	2	14
☒	**B**	2	6
☒	**C**	4	4
☒	**D**	4	10

(ii) What is the molecular formula of the cyclic hydrocarbon.

(1)

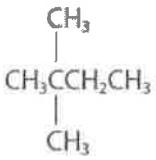
☐ **A** C_5H_5
☐ **B** C_5H_8
☐ **C** C_6H_{12}
☐ **D** C_6H_8

(Total for Question 16 = 2 marks)

17. The compounds in the table are isomers.

Compound	Structural formula	Boiling temperature / °C
hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$	69
2-methylpentane	$CH_3CH_2CH_2CH(CH_3)$	61
3-methylpentane	$CH_3CH_2CH(CH_3)CH_2CH_3$	63

Which is most likely to be the boiling temperature of another isomer, 2,2-dimethylbutane?
The structure of 2,2-dimethylbutane is



☐ **A** 40°C
☐ **B** 50°C
☐ **C** 60°C
☐ **D** 70°C

(Total for Question 17 = 1 mark)

18. Which molecule can exist as E-Z isomers?

☒ **A** 2-chloro-4-ethylhex-3-ene
☒ **B** 3-chloro-2-methylhex-2-ene
☒ **C** 2,3-dimethylhex-2-ene
☒ **D** 2,5-dichlorohex-3-ene

(Total for Question 18 = 1 mark)

19. The formula of phosgene is $COCl_2$.

What is the total number of **atoms** in 9.9 g of phosgene?

[Avogadro constant (L) = 6.02×10^{23} mol^{-1} M_r value: $COCl_2 = 99.0$]

- ☐ **A** 1.51×10^{22}
- ☐ **B** 6.02×10^{22}
- ☐ **C** 1.81×10^{23}
- ☐ **D** 2.41×10^{23}

(Total for Question 19 = 1 mark)

20. Bottles of potassium manganate(VII), $KMnO_4$, have three hazard warning labels.

One of these is shown.



This hazard symbol means that potassium manganate(VII) is liable to

- ☐ **A** burn easily in the presence of oxygen
- ☒ **B** explode
- ☒ **C** react dangerously with oxygen
- ☐ **D** react vigorously with reducing agents

(Total for Question 20 = 1 mark)

21. Concentrations in mixtures can be given in units of parts per million (ppm).

(a) A sample of a gaseous mixture contains 2.19 % carbon dioxide by mass.

What is the concentration of carbon dioxide in parts per million (ppm) by mass in this sample?

(1)

☐ **A** 2.19×10^{6}
☐ **B** 2.19×10^{4}
☐ **C** 2.19×10^{-4}
☐ **D** 2.19×10^{-6}

(b) A solution of lead nitrate has a concentration of 15 ppm by mass.

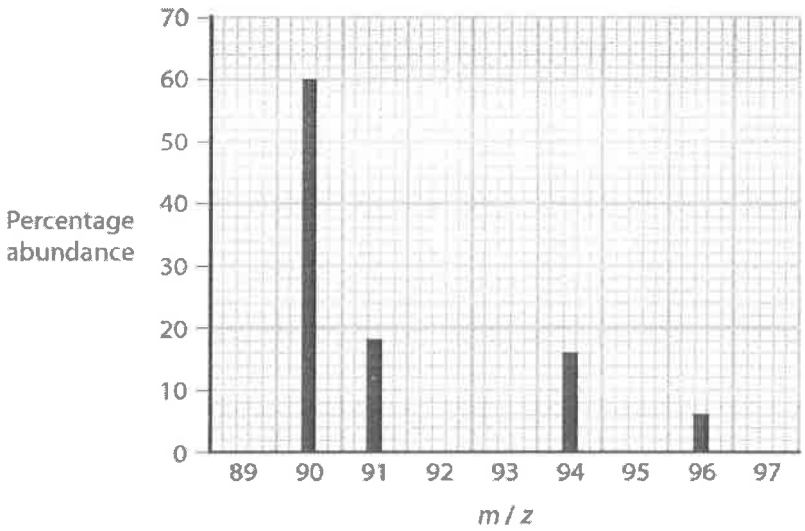
What is the mass of lead nitrate in 400 g of this solution?

(1)

☒ **A** 6.00×10^{-3} g
☒ **B** 6.00×10^{-6} g
☒ **C** 6.00×10^{-3} kg
☒ **D** 6.00×100 kg

(Total for Question 21 = 2 marks)

22. The mass spectrum of an element is shown.



What is the relative atomic mass of this element?

☐ **A** 90.0
☐ **B** 90.9
☐ **C** 91.2
☐ **D** 92.8

(Total for Question 22 = 1 mark)
TOTAL FOR SECTION A = 25 MARKS

SECTION B

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

23. The structure of a compound **X** is shown. **X** is present in petrol.



(a)(i) Give the molecular formula and IUPAC name for **X**.

(2)

Molecular formula: .....

Name: .....

(ii) Name the industrial process used to produce **X** from the straight-chain isomer.

(1)

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(b) Heptane is also present in petrol.

(i) Write an equation for the **complete** combustion of heptane. Include state symbols.

(2)

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(ii) Identify, by name or formula, a pollutant that may result from the **incomplete** combustion of heptane.

(1)

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(c) State the reason why compounds, such compound **X**, have a higher percentage in petrol compared to straight-chain alkanes.

(1)

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(d) Commercial diesel fuel is a mixture of hydrocarbons.

One of the components of commercial diesel fuel is a hydrocarbon with the formula $C_{12}H_{26}$.

An equation for the complete combustion of $C_{12}H_{26}$ is shown.

$$C_{12}H_{26} + 18½O_2 \rightarrow 12CO_2 + 13H_2O$$

(i) Calculate the maximum volume, in m^3, of carbon dioxide gas produced in an engine by the complete combustion of 1.00 **kg** of $C_{12}H_{26}$ at 200°C, at a pressure of 6.0×10^6 Pa.

[The ideal gas equation is $pV = nRT$ Gas constant, $R = 8.31$ J mol^{-1} K^{-1}]

(4)

(ii) Recently, sales of electric cars have increased.

Give **two** environmental benefits of using electric cars. Justify your answers.

(2)

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(Total for Question 23 = 13 marks)

24. This question is about alkanes and some of their reactions.

(a) Hexane is a saturated hydrocarbon.

State what is meant by the term **saturated hydrocarbon**.

Your answer should refer to both words in the term.

(2)

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(b) Another alkane, ethane, can be converted into chloroethane.

(i) Give the conditions required to convert ethane into chloroethane.

(1)

Conditions .....

(ii) What is the **mechanism** and **type** of reaction by which ethane is converted into chloroethane?

(2)

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(iii) When ethane reacts with gaseous chlorine, the initiation step is bond breaking in the chlorine molecule to form chlorine free radicals. The equation for this step is shown.

$$Cl_2(g) \rightarrow 2Cl\bullet(g)$$

Rewrite the initiation step showing curly arrows.

(1)

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(iv) Write two equations for the propagation step.

(2)

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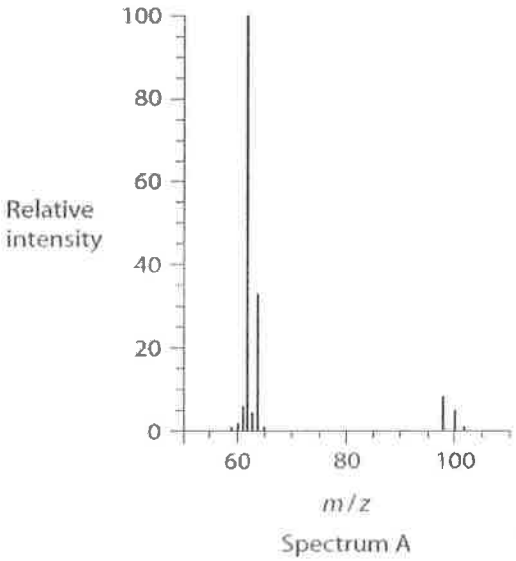
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(c) Further reactions of chloroethane result in the formation of small amounts of the isomers 1,1-dichloroethane and 1,2-dichloroethane.

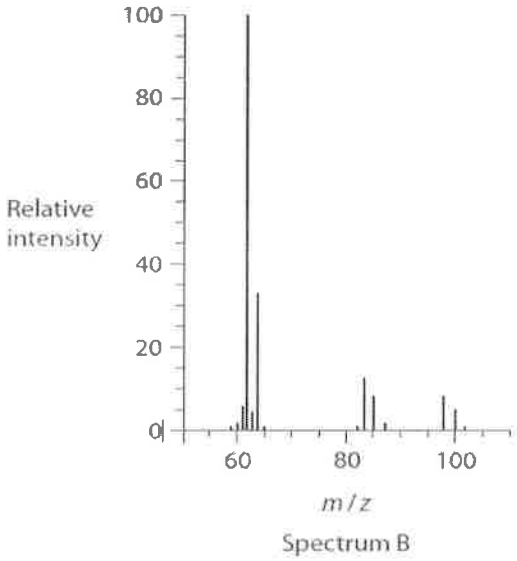
(i) Using structural formulae, write equations to show the formation of these products. Curly arrows are not required.

(3)

(ii) The mass spectra of the two isomers of dichloroethane are shown.



Spectrum A



Spectrum B

Deduce the molecular formulae of the species responsible for the molecular ion peaks at m/z 98, 100 and 102.
The molecular formulae for the species producing these peaks are the same in both spectra.

(2)

(iii) State why in both spectra the peaks at 98, 100 and 102 have different relative intensities.

(1)

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(iv) Explain how the presence of the peaks at 83, 85 and 87 in Spectrum B allows the identification of the isomer responsible for this spectrum.

(2)

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(Total for Question 24 = 16 marks)

25. The question is about electronegativity and its influence on bonding.

(a) State what is meant by the term electronegativity.

(1)

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(b) Explain the trend in electronegativity going down Group 7 elements.

(3)

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(c) Describe what you understand by the term 'continuum of bonding type' in relation to electronegativities.

(2)

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(d) The table gives data for chlorine and chlorine compounds of some Period 3 elements. The data show evidence that the type of bonding in compounds is a continuum across Period 3.

	Empirical formula	Melting point/°C	Electrical conductivity
Sodium chloride	NaCl	801	Yes, when molten
Magnesium chloride	$MgCl_2$	714	Yes, when molten
Aluminium chloride	$AlCl_3$	180 (sublimes)	No
Silicon tetrachloride	$SiCl_4$	-70	No
Phosphorus(III) chloride	PCl_3	-112	No
Chlorine	Cl_2	-102	No

Discuss the extent to which the data in the table demonstrate a continuum of bonding type. Include reference to the data of **three** of the substances in the table with different types of bonding.

(3)

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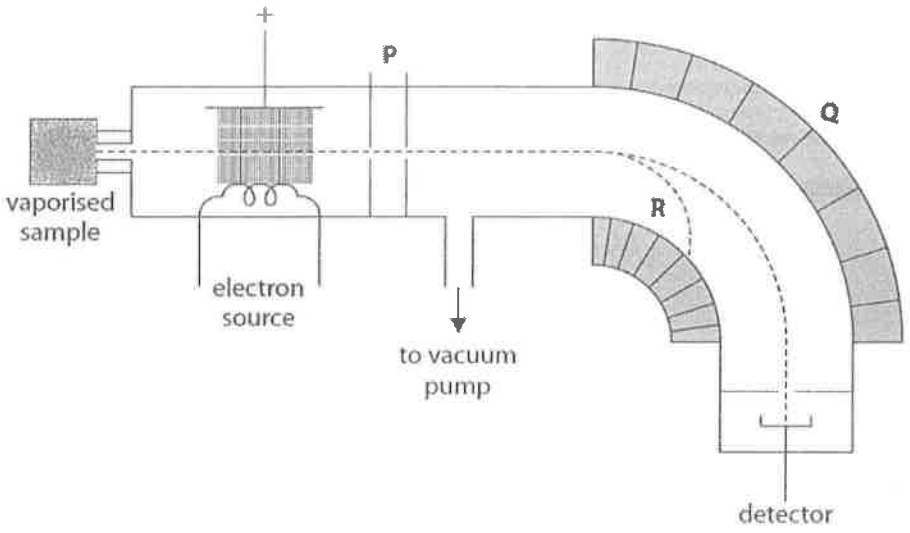
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(Total for Question 25 = 9 marks)

26. This question is about mass spectrometery.

(a) A diagram of a mass spectrometer is shown.



(i) Identify **P** and state its purpose.

(2)

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(ii) Identify **Q**.

(1)

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(iii) Suggest **two** ways in which the ions following path **R** could differ from the ions that reach the detector.

(2)

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(b) The mass spectrum of magnesium shows the presence of three isotopes.

(i) Complete the table to show the numbers of subatomic particles in the atom of each isotope.

(2)

Isotope mass number	Number of protons	Number of neutrons	Number of electrons
24			
25			
26			

(ii) Explain, with reference to the subatomic particles of the isotopes of magnesium, the meaning of the term isotope.
Quote data from the table in (b)(i).

(2)

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(c) State **two** further uses of mass spectrometers.

(2)

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(Total for Question 26 = 11 marks)

27. This question is about some elements of the Periodic Table.

(a) The first ionisation energies of some elements in Period 2 are shown.

Element	Li	Be	B	C	N	O	F	Ne
First ionisation energy/kJmol^{-1}	520	900	801	1086	1402		1681	2081

(i) Explain the general trend in first ionisation energy across Period 2.

(2)

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(ii) Predict a value for the first ionisation energy of oxygen. Justify your answer.

(3)

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(b) The second ionisation energy of lithium, Li, is 7298 kJ mol^{-1}.

(i) Write the equation for the second ionisation energy of lithium. Include state symbols.

(2)

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(ii) Explain the large difference between the first and second ionisation energies of lithium.

(2)

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(c) Both chromium and calcium can form ions with a +2 charge.
Explain which of chromium or calcium most easily forms a +2 ion using all of the data in the table.

(3)

Element	Atomic number	1st ionisation energy / $kJmol^{-1}$	2nd ionisation energy / $kJmol^{-1}$	Metallic radius/nm
Chromium	24	653	1592	0.129
Calcium	20	590	1145	0.197

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(d) Beryllium reacts with chlorine to form beryllium chloride.
In the gas phase, beryllium chloride exists both as a simple molecule, $BeCl_2$, and as a dimer, Be_2Cl_4.

(i) Draw a dot-and-cross diagram of the molecule, $BeCl_2$.

(1)

(ii) Explain the shape and bond angle in the molecule $BeCl_2$.

(4)

Shape .....

Bond angle .....

Explanation

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(iii) Draw a diagram to show how two beryllium chloride molecules bond together to form the dimer, Be_2Cl_4, stating the type of bond involved.

(2)

Type of bond .....

Diagram

(Total for Question 27 = 19 marks)

28. Oxygen is vital in the treatment of respiratory diseases. Oxygen is traditionally produced by the fractional distillation of air.

Liquid oxygen is transported across the world.

Liquid oxygen has a density of $1140\ g.dm^{-3}$. Given $density = \frac{mass}{volume}$.

(a) Calculate the volume of gas, in $\mathbf{m^3}$, measured at room temperature and pressure (r.t.p.) that can be obtained from a bottle containing 13.9 dm^3 of liquid oxygen.
[Molar volume at r.t.p. = 24.0 $dm^3\ mol^{-1}$]

(4)

(b) The total mass of the bottle is 80.0 kg when it is full of oxygen.
Calculate the mass of an empty bottle, using your working from (c)(i).
Give your answer to an appropriate number of significant figures.

(1)

(c) Explain why the container needs to have such a large mass.

(2)

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(Total for Question 28 = 7 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

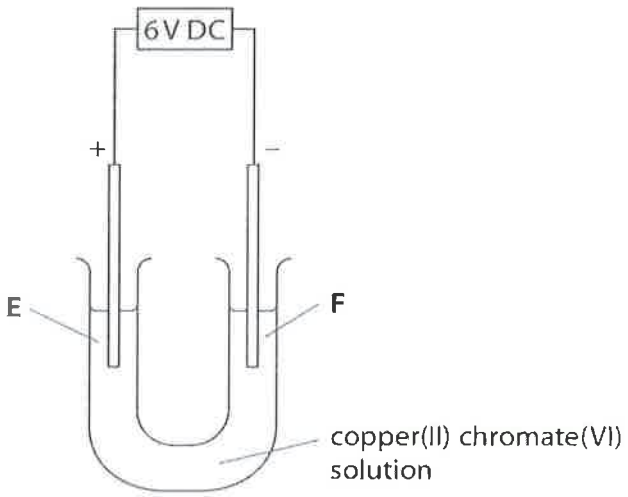
Answer ALL the questions in this section.
You should aim to spend no more than 20 minutes on this section.
For each question, select one answer from A to D and put a cross in the box.
If you change your mind, put a line through ☒ the box and then mark your new answer with a cross. ☒

1. Ionic bonding is the strong electrostatic attraction between

(1)
- ☒ **A** anions and cations
- ☐ **B** atoms and delocalised electrons
- ☐ **C** cations and delocalised electrons
- ☐ **D** two nuclei and a shared pair of electrons

(Total for Question 1 = 1mark)

2. An aqueous solution of green copper(II) chromate(VI) was electrolysed using the apparatus shown in the diagram.



The colours of the solutions in regions **E** and **F** after the electrolysis has occurred are

(1)
- ☐ **A** blue in region **E** and yellow in region **F**
- ☒ **B** yellow in region **E** and blue in region **F**
- ☐ **C** green in region **E** and colourless in region **F**
- ☐ **D** colourless in region **E** and green in region **F**

(Total for Question 2 = 1mark)

3. Some ionic radii are given in the table.

Ion	Ionic radius/nm
Na^+	0.102
Mg^{2+}	0.072
Cl^-	0.180
Br^-	0.195

The formula of the compound, formed from the ions in the table, that has the strongest ionic bonding is

- ☐ **A** NaCl
- ☒ **B** $MgCl_2$
- ☐ **C** NaBr
- ☐ **D** $MgBr_2$

(Total for Question 3 = 1mark)

4. The names of four substances are given.

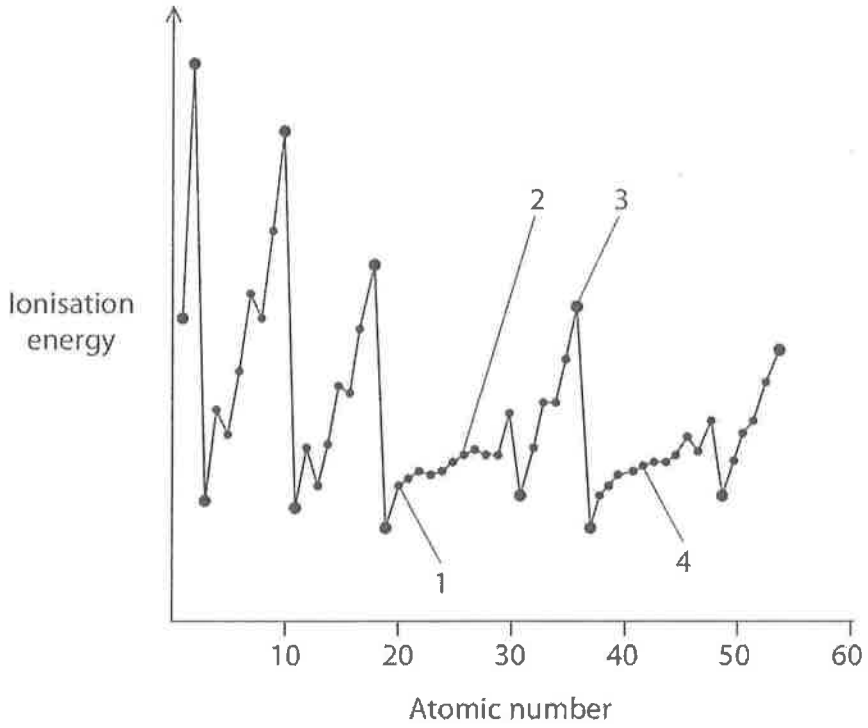
Substance	Name
P	copper
Q	iodine
R	silicon(IV) dioxide
S	sodium chloride

Which of these substances has a high melting temperature, and conducts electricity when solid and when molten?

- ☒ **A** Substance **P**
- ☒ **B** Substance **Q**
- ☒ **C** Substance **R**
- ☒ **D** Substance **S**

(Total for Question 4 = 1mark)

5. Which of the labels 1–4 identifies a p-block element in Period 4?



- ☒ **A** 1
- ☒ **B** 2
- ☒ **C** 3
- ☐ **D** 4

1

(Total for Question 5 = 1mark)

6. What is the stable electronic configuration of a copper atom?

- ☒ **A** [Ar] $4s^1\ 3d^{10}$
- ☐ **B** [Ar] $4s^2\ 3d^9$
- ☐ **C** [Ar] $4s^2\ 4p^1\ 3d^8$
- ☐ **D** [Ar] $4s^2\ 4p^2\ 3d^7$

1

(Total for Question 6 = 1mark)

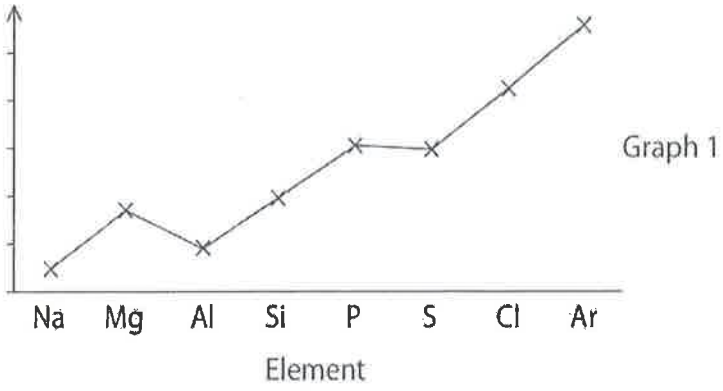
7. Which is the most likely sequence of values, in kJ mol^{-1}, for the first four ionisation energies of barium?

- ☐ **A** 1000 2251 3361 4564
- ☐ **B** 496 4563 6913 9544
- ☒ **C** 503 965 3458 4530
- ☐ **D** 578 1817 2745 11 578

1

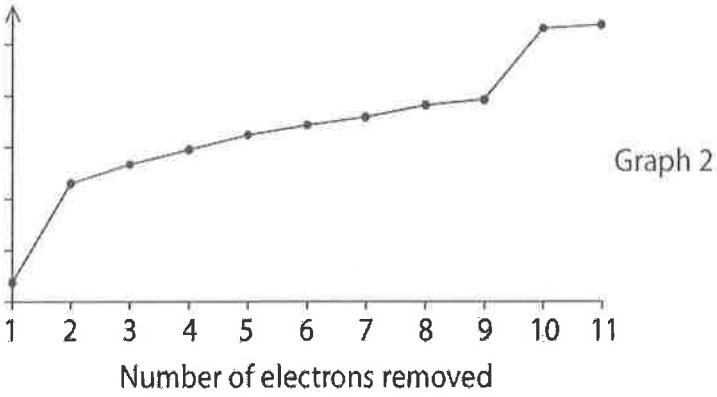
(Total for Question 7 = 1 mark)

8. Graph 1 shows the variation in first ionisation energy with increasing atomic number.



Graph 1

Graph 2 shows the variation in successive ionisation energies for sodium.



Graph 2

(a) What quantities were plotted on the y-axes to produce these graphs?

(1)

	Graph 1 First ionisation energy of successive elements	Graph 2 Successive ionisation energies of sodium
☒ A	actual value	log of value
☒ B	log of value	log of value
☒ C	log of value	actual value
☒ D	actual value	actual value

(b) What is the number of **quantum** shells in a sodium atom suggested by Graph 2?

(1)

☐ A Two
☒ B Three
☐ C Four
☐ D Six

(Total for Question 8 = 2 marks)

9. What is the shape of the ICl_4^- ion?

- ☐ **A** octahedral
- ☒ **B** square planar
- ☐ **C** tetrahedral
- ☐ **D** trigonal bipyramidal

(Total for Question 9 = 1mark)

10. Which describes the polarity of the P—Cl bond and the polarity of the phosphorus(III) chloride, PCl_3, molecule?

		Polarity of the P—Cl bond	Polarity of molecule
☐	**A**	Non-polar	Non-polar
☐	**B**	Non-polar	Polar
☒	**C**	Polar	non-polar
☐	**D**	polar	polar

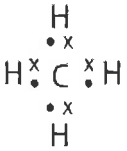
(Total for Question 10 = 1mark)

11. The O–H bond in water is polar because, when compared with the hydrogen atom, the oxygen atom has

- ☐ **A** a higher mass number
- ☐ **B** a larger atomic radius
- ☒ **C** greater electronegativity
- ☐ **D** more electrons

(Total for Question 11 = 1mark)

12. Four dot-and-cross electron diagrams are shown.



W



X



Y



Z

Which diagrams are correct?

- ☒ **A** W, X, Y and Z only
- ☒ **B** W, Y and Z only
- ☒ **C** W and Z only
- ☒ **D** X and Z only

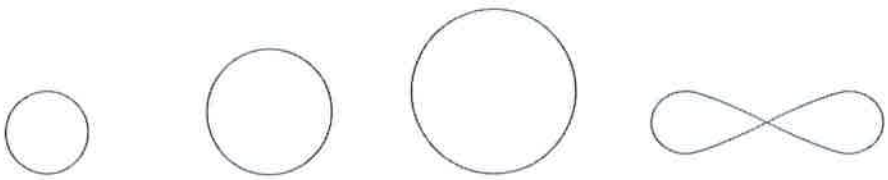
(Total for Question 12 = 1 mark)

13. Which molecule contains the greatest number of π bonds?

- ☒ **A** CO_2
- ☒ **B** C_2H_4
- ☒ **C** C_2H_6
- ☒ **D** C_4H_8

(Total for Question 13 = 1 mark)

14. The diagrams show the shape and relative size of four of the atomic orbitals occupied in a magnesium atom.



E **F** **G** **H**

Which diagram shows a 2s orbital?

- ☒ **A** E
- ☒ **B** F
- ☒ **C** G
- ☒ **D** H

(Total for Question 14 = 1 mark)

15. The number of structural isomers with formula C_6H_{14} is

- ☐ **A** 3
- ☐ **B** 4
- ☒ **C** 5
- ☐ **D** 6

(Total for Question 15 = 1 mark)

16. A cyclic hydrocarbon has the structure shown.



(i) How many pi (π) and sigma (σ) bonds are present in the molecule?

(1)

		pi (π) bonds	sigma (σ) bonds
☒	**A**	2	14
☐	**B**	2	6
☒	**C**	4	4
☒	**D**	4	10

(ii) What is the molecular formula of the cyclic hydrocarbon.

(1)

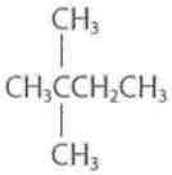
- ☒ **A** C_5H_5
- ☒ **B** C_5H_8
- ☒ **C** C_6H_{12}
- ☒ **D** C_6H_8

(Total for Question 16 = 2 marks)

17. The compounds in the table are isomers.

Compound	Structural formula	Boiling temperature / °C
hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$	69
2-methylpentane	$CH_3CH_2CH_2CHCH_3$ (with CH_3 branch)	61
3-methylpentane	$CH_3CH_2CHCH_2CH_3$ (with CH_3 branch)	63

Which is most likely to be the boiling temperature of another isomer, 2,2-dimethylbutane?
The structure of 2,2-dimethylbutane is



(1) ✓
- ☐ **A** 40°C
- ☒ **B** 50°C
- ☐ **C** 60°C
- ☐ **D** 70°C

(Total for Question 17 = 1 mark)

18. Which molecule can exist as E-Z isomers?

(1) ✓
- ☒ **A** 2-chloro-4-ethylhex-3-ene
- ☒ **B** 3-chloro-2-methylhex-2-ene
- ☒ **C** 2,3-dimethylhex-2-ene
- ☒ **D** 2,5-dichlorohex-3-ene

(Total for Question 18 = 1 mark)

19. The formula of phosgene is $COCl_2$.

What is the total number of **atoms** in 9.9 g of phosgene?

[Avogadro constant (L) = 6.02×10^{23} mol^{-1} M_r value: $COCl_2 = 99.0$]

- ☒ **A** 1.51×10^{22}
- ☒ **B** 6.02×10^{22}
- ☒ **C** 1.81×10^{23}
- ☒ **D** 2.41×10^{23} ✓ (1)

(Total for Question 19 = 1 mark)

20. Bottles of potassium manganate(VII), $KMnO_4$, have three hazard warning labels.

One of these is shown.



This hazard symbol means that potassium manganate(VII) is liable to

- ☒ **A** burn easily in the presence of oxygen
- ☒ **B** explode
- ☒ **C** react dangerously with oxygen
- ☒ **D** react vigorously with reducing agents ✓ (1)

(Total for Question 20 = 1 mark)

21. Concentrations in mixtures can be given in units of parts per million (ppm).

(a) A sample of a gaseous mixture contains 2.19 % carbon dioxide by mass.

What is the concentration of carbon dioxide in parts per million (ppm) by mass in this sample?

(1)

- ☒ **A** 2.19×10^{6}
- ☒ **B** 2.19×10^{4}
- ☒ **C** 2.19×10^{-4}
- ☒ **D** 2.19×10^{-6}

(b) A solution of lead nitrate has a concentration of 15 ppm by mass.

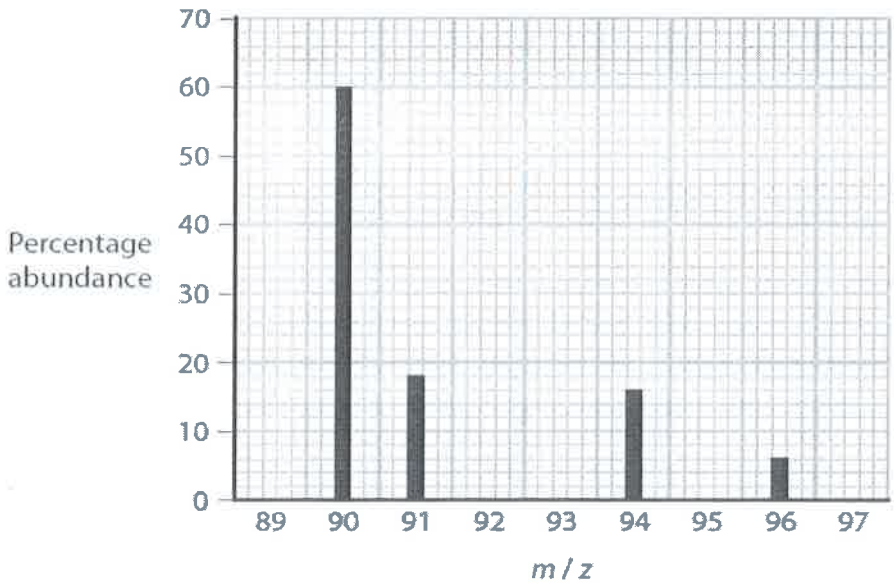
What is the mass of lead nitrate in 400 g of this solution?

(1)

- ☒ **A** 6.00×10^{-3} g
- ☒ **B** 6.00×10^{-6} g
- ☒ **C** 6.00×10^{-3} kg
- ☒ **D** 6.00×100 kg

(Total for Question 21 = 2 marks)

22. The mass spectrum of an element is shown.



What is the relative atomic mass of this element?

- ☐ **A** 90.0
- ☐ **B** 90.9
- ☒ **C** 91.2
- ☐ **D** 92.8

(Total for Question 22 = 1 mark)

TOTAL FOR SECTION A = 25 MARKS

SECTION B

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

23. The structure of a compound **X** is shown. **X** is present in petrol.



(a)(i) Give the molecular formula and IUPAC name for **X**.

(2)

Molecular formula: C_8H_{18} ✓1

Name: 2,2,4-trimethylpentane ✓1

(ii) Name the industrial process used to produce **X** from the straight-chain isomer.

(1)

reforming ✓1

(b) Heptane is also present in petrol.

(i) Write an equation for the **complete** combustion of heptane. Include state symbols.

(2)

$C_7H_{16}(l) + 11O_2(g) \longrightarrow 7CO_2(g) + 8H_2O(l)$ ✓2

(ii) Identify, by name or formula, a pollutant that may result from the **incomplete** combustion of heptane.

(1)

CO / carbon monoxide ✓1

(c) State the reason why compounds, such compound **X**, have a higher percentage in petrol compared to straight-chain alkanes.

(1)

They reduce the engines knocking ✓1

(d) Commercial diesel fuel is a mixture of hydrocarbons.

One of the components of commercial diesel fuel is a hydrocarbon with the formula $C_{12}H_{26}$.

An equation for the complete combustion of $C_{12}H_{26}$ is shown.

$$C_{12}H_{26} + 18\frac{1}{2}O_2 \rightarrow 12CO_2 + 13H_2O$$

(i) Calculate the maximum volume, in m^3, of carbon dioxide gas produced in an engine by the complete combustion of 1.00 **kg** of $C_{12}H_{26}$ at 200°C, at a pressure of 6.0×10^6 Pa.

[The ideal gas equation is $pV = nRT$ Gas constant, $R = 8.31$ J mol^{-1} K^{-1}]

(4)

$n_{CO_2} = 12 \times n_{C_{12}H_{26}} = \frac{12 \times 10^3}{170} = 70.6$ mol (1)

$T = 200 + 273 = 473$ K. (1)

$\Rightarrow V_{CO_2} = \frac{12 \times 10^3 \times 8.31 \times 473}{170 \times 6.0 \times 10^6}$ (1)

$V_{CO_2} = 46.2 \times 10^{-3}$ m^3

(ii) Recently, sales of electric cars have increased.

Give **two** environmental benefits of using electric cars. Justify your answers.

(2)

They are carbon neutral while they are running (1)

An overall reduction of CO_2 emission, as the need for crude oil is lowered. (1)

(Total for Question 23 = 13 marks)

24. This question is about alkanes and some of their reactions.

(a) Hexane is a saturated hydrocarbon.

State what is meant by the term **saturated hydrocarbon**.

Your answer should refer to both words in the term.

(2)

It's only formed of carbon and hydrogen atoms where all carbon atoms are singly bonded. (1) (1)

(b) Another alkane, ethane, can be converted into chloroethane.

(i) Give the conditions required to convert ethane into chloroethane.

(1)

Conditions U.V light / sunlight. (1)

(ii) What is the **mechanism** and **type** of reaction by which ethane is converted into chloroethane?

(2)

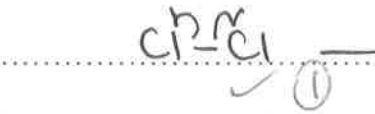
free radical substitution (1) (1)

(iii) When ethane reacts with gaseous chlorine, the initiation step is bond breaking in the chlorine molecule to form chlorine free radicals. The equation for this step is shown.

$$Cl_2(g) \rightarrow 2Cl\bullet(g)$$

Rewrite the initiation step showing curly arrows.

(1)

 (1)

(iv) Write two equations for the propagation step.

(2)

$Cl^{\bullet} + C_2H_6 \longrightarrow HCl + C_2H_5^{\bullet}$ (1)

$C_2H_5^{\bullet} + Cl_2 \longrightarrow C_2H_5Cl + Cl^{\bullet}$ (1)

(c) Further reactions of chloroethane result in the formation of small amounts of the isomers 1,1-dichloroethane and 1,2-dichloroethane.

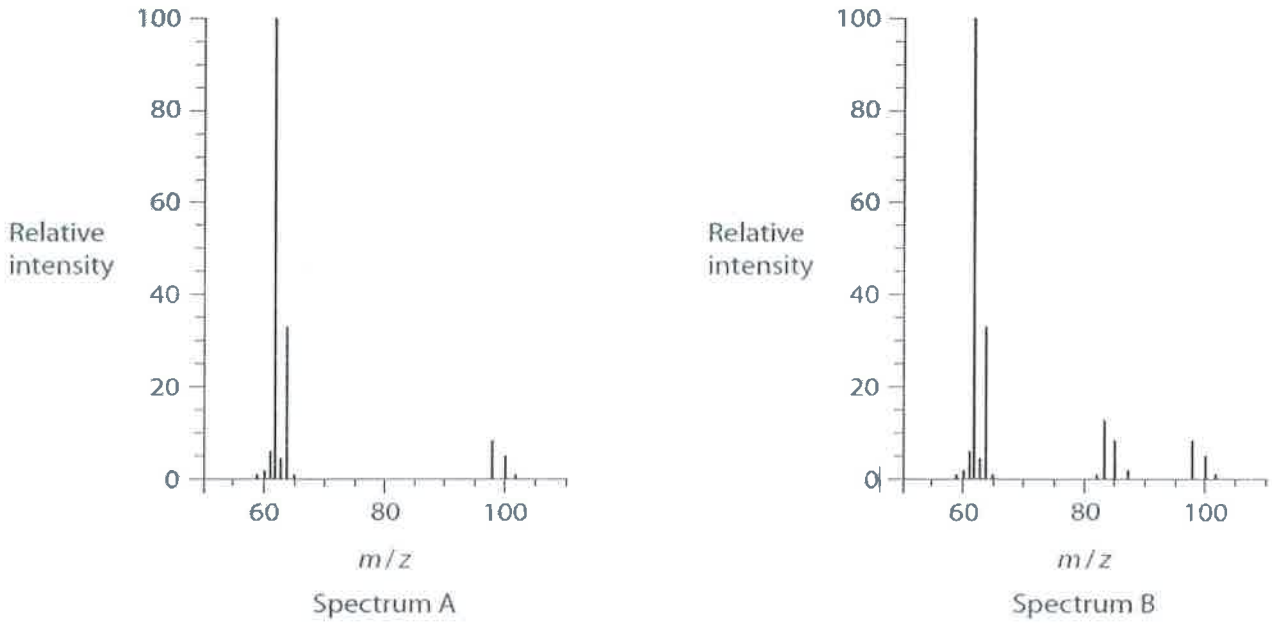
(i) Using structural formulae, write equations to show the formation of these products. Curly arrows are not required. (3)

$CH_3CH_2Cl + Cl^\bullet \rightarrow CH_3\dot{C}HCl + HCl$

$CH_3\dot{C}HCl + Cl_2 \rightarrow CH_3CHCl_2 + Cl^\bullet$ (1)
1,1-dichloroethane

$\dot{C}H_2CH_2Cl + Cl_2 \rightarrow CH_2ClCH_2Cl + Cl^\bullet$ (1)
1,2-dichloroethane

(ii) The mass spectra of the two isomers of dichloroethane are shown.



Deduce the molecular formulae of the species responsible for the molecular ion peaks at m/z 98, 100 and 102.
The molecular formulae for the species producing these peaks are the same in both spectra. (2)

$(C_2H_4{}^{35}Cl{}^{35}Cl)^+$ @ m/z = 98 (1)

$(C_2H_4{}^{35}Cl{}^{37}Cl)^+$ @ m/z = 100

$((C_2H_4{}^{37}Cl{}^{37}Cl)^+$ @ m/z = 102 (1)

(iii) State why in both spectra the peaks at 98, 100 and 102 have different relative intensities.

(1)

The 2 isotopes of chlorine exist at different ratio. ✓ (1)

(iv) Explain how the presence of the peaks at 83, 85 and 87 in Spectrum B allows the identification of the isomer responsible for this spectrum.

(2)

The m/z = 83, 85 or 87 represent species including both Cl atoms (the molar mass of $C_2H_4Cl_2$ is 99 $g.mol^{-1}$) ✓ (1)

Therefore spectrum B is for 1,1-dichloroethane. ✓ (1)

(Total for Question 24 = 16 marks)

25. The question is about electronegativity and its influence on bonding.

(a) State what is meant by the term electronegativity.

(1)

It's the ability of an atom to pull the bonding pair of $\bar{e}$. ✓1

(b) Explain the trend in electronegativity going down Group 7 elements.

(3)

Going down group VII, the nuclear charge increases ✓1 as well as the number of energy levels increases ✓1 increasing the size of atoms, which will lead to a decrease in the ability to attract the bonding pair. ✓1

(c) Describe what you understand by the term 'continuum of bonding type' in relation to electronegativities.

(2)

There are 2 extreme / discrete type of bonding: covalent and ionic. ✓1

A polar covalent bond represents a continuum type of bonding where the covalent / ionic character changes according to the elements. ✓1

(d) The table gives data for chlorine and chlorine compounds of some Period 3 elements. The data show evidence that the type of bonding in compounds is a continuum across Period 3.

	Empirical formula	Melting point/°C	Electrical conductivity
Sodium chloride	NaCl	801	Yes, when molten
Magnesium chloride	$MgCl_2$	714	Yes, when molten
Aluminium chloride	$AlCl_3$	180 (sublimes)	No
Silicon tetrachloride	$SiCl_4$	-70	No
Phosphorus(III) chloride	PCl_3	-112	No
Chlorine	Cl_2	-102	No

Discuss the extent to which the data in the table demonstrate a continuum of bonding type. Include reference to the data of **three** of the substances in the table with different types of bonding.

(3)

NaCl / $MgCl_2$ is an ionic compound with high T'm, reflecting its giant structure, and conducts electricity when it's molten. ✓ (1)

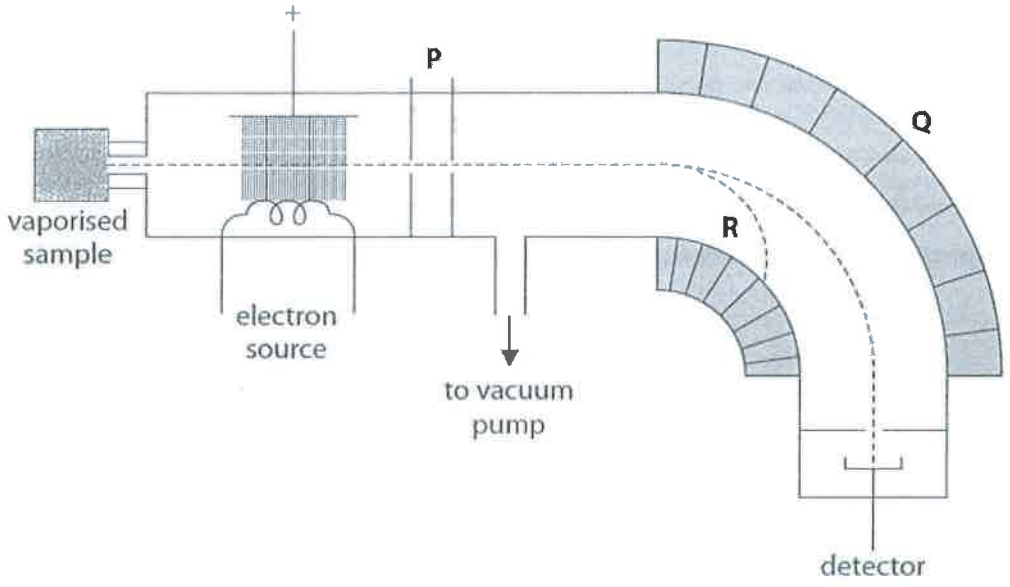
Cl_2 / PCl_3 / $SiCl_4$ simple covalent structures with low T'm and unable to conduct electricity. ✓ (1)

While $AlCl_3$ is ionic with covalent character as it doesn't conduct electricity but sublimes at a relatively low T°. ✓ (1)

(Total for Question 25 = 9 marks)

26. This question is about mass spectrometery.

(a) A diagram of a mass spectrometer is shown.



(i) Identify **P** and state its purpose. (2)

It's the electric field ✓1

It accelerates the ionised species in order to have a uniform velocity. ✓1

(ii) Identify **Q**. (1)

magnetic field ✓1

(iii) Suggest **two** ways in which the ions following path **R** could differ from the ions that reach the detector. (2)

The ions could be lighter ✓1 or could have a charge greater than +1 ✓1

(b) The mass spectrum of magnesium shows the presence of three isotopes.

(i) Complete the table to show the numbers of subatomic particles in the atom of each isotope.

(2)

Isotope mass number	Number of protons	Number of neutrons	Number of electrons
24	12	12	12
25	12	13	12
26	12	14	12

(2)

(ii) Explain, with reference to the subatomic particles of the isotopes of magnesium, the meaning of the term isotope.
Quote data from the table in (b)(i).

(2)

$^{24}_{12}Mg$ and $^{25}_{12}Mg$ are atoms of the same element having equal number of protons but different number of neutrons

(2)

(c) State **two** further uses of mass spectrometers.

(2)

Carbon dating

Identifying athletes' cheats

Discovering new elements

(2)

(Total for Question 26 = 11 marks)

27. This question is about some elements of the Periodic Table.

(a) The first ionisation energies of some elements in Period 2 are shown.

Element	Li	Be	B	C	N	O	F	Ne
First ionisation energy/kJmol^{-1}	520	900	801	1086	1402		1681	2081

(i) Explain the general trend in first ionisation energy across Period 2.

(2)

Going across Period 2 the nuclear charge increases yet the number of energy level remains the same which will decrease the atomic radius. This will increase the attraction between the nucleus and the outer e^- leading to an increase in I.E.

(ii) Predict a value for the first ionisation energy of oxygen. Justify your answer.

(3)

1st I.E of oxygen : [1150 - 1300 kJ.mol^{-1}] ✓ (1)

$_7N$: $1s^2\ 2s^2$ [↑|↑|↑] $_8O$: $1s^2\ 2s^2$ [↑↓|↑|↑]

Although oxygen's nuclear charge is greater than that of nitrogen (1) yet, the first e^- to be removed is from a 2p orbital occupied by a pair of e^-. ✓

The repulsion between the $2e^-$ favours the (1) removal of one explaining the slight ✓ decrease in 1st I.E value.

(b) The second ionisation energy of lithium, Li, is 7298 kJ mol^{-1}.

(i) Write the equation for the second ionisation energy of lithium. Include state symbols.

(2)

$Li^{+}(g) \longrightarrow Li^{2+}(g) + e^{-}$ ✓✓ (2)

(ii) Explain the large difference between the first and second ionisation energies of lithium.

(2)

Li : $1s^2$ $2s^1$

The 2nd e^- is being removed from a new energy level which is the closest to the nucleus and where the shielding is at its minimum. ✓ (1) (1)

(c) Both chromium and calcium can form ions with a +2 charge.
Explain which of chromium or calcium most easily forms a +2 ion using all of the data in the table.

(3)

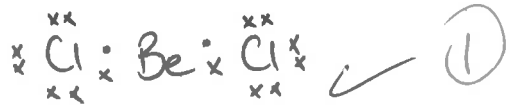
Element	Atomic number	1st ionisation energy / $kJmol^{-1}$	2nd ionisation energy / $kJmol^{-1}$	Metallic radius/nm
Chromium	24	653	1592	0.129
Calcium	20	590	1145	0.197

1st I.E of Cr + 2nd I.E of Cr = 2,245 $kJ.mol^{-1}$ ✓
1st I.E of Ca + 2nd I.E of Ca = 1,735 $kJ.mol^{-1}$ ✓ (1)
Both Ca and Cr have 4 energy levels in their e^- cloud ✓, (1) yet the high nuclear charge and the small atomic radius (1) of Cr increase the values ✓ of (1st I.E + 2nd I.E) making the formation of Cr^{2+} more difficult than that of Ca^{2+} ✓

(d) Beryllium reacts with chlorine to form beryllium chloride.
In the gas phase, beryllium chloride exists both as a simple molecule, $BeCl_2$, and as a dimer, Be_2Cl_4.

(i) Draw a dot-and-cross diagram of the molecule, $BeCl_2$.

(1)



(ii) Explain the shape and bond angle in the molecule $BeCl_2$.

(4)

Shape ..... linear ✓(1) .....

Bond angle ..... 180° ✓(1) .....

Explanation

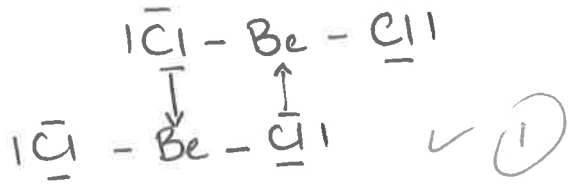
Around the central atom Be exist 2 bonding pairs and no lone pairs ✓(1) Thes bonding pairs, and according to the EPR theory, arrange themselves to a minimum repulsion ✓(1)

(iii) Draw a diagram to show how two beryllium chloride molecules bond together to form the dimer, Be_2Cl_4, stating the type of bond involved.

(2)

Type of bond ..... dative bond ✓(1) .....

Diagram



✓(1)

(Total for Question 27 = 19 marks)

28. Oxygen is vital in the treatment of respiratory diseases. Oxygen is traditionally produced by the fractional distillation of air.
Liquid oxygen is transported across the world.

Liquid oxygen has a density of $1140\ g.dm^{-3}$. Given $density = \frac{mass}{volume}$.

(a) Calculate the volume of gas, in $\mathbf{m^3}$, measured at room temperature and pressure (r.t.p.) that can be obtained from a bottle containing 13.9 dm^3 of liquid oxygen.
[Molar volume at r.t.p. = 24.0 $dm^3\ mol^{-1}$]

(4)

$n_{O_2(l)} = 13.9 \times 1140 = 15,846\ g$ ✓(1)

$\Rightarrow n_{O_2(l)} = \frac{15,846}{32} = 495.1875\ mol$ ✓(1)

$n_{O_2(g)} = n_{O_2(l)} = \frac{V_{O_2}}{V_M}$ ✓(1)

$\Rightarrow V_{O_2} = 495.1875 \times 24 = 11,884.5\ dm^3$ ✓(1)
$= 11.9\ m^3$

(b) The total mass of the bottle is 80.0 kg when it is full of oxygen.
Calculate the mass of an empty bottle, using your working from (c)(i).
Give your answer to an appropriate number of significant figures.

(1)

mass of empty bottle = 80 − 15.8
= 64.2 kg ✓(1)

(c) Explain why the container needs to have such a large mass.

(2)

The container needs to have thick walls ✓
in order to withstand that much pressure. ✓(2)

(Total for Question 28 = 7 marks)
TOTAL FOR SECTION B = 75 MARKS
TOTAL FOR PAPER = 100 MARKS