Part 2

Practice Exam 1

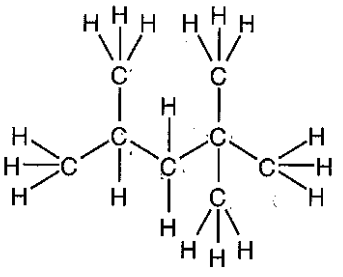
Section A – Multiple-choice questions

Instructions for Section A

Answer all questions. Circle the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Question 1



The systematic name for the hydrocarbon shown above is

A. 2,2,4-trimethylpentane.
B. octane.
C. 2,2-dimethylhexane.
D. 2,4,4-trimethylpentane.

Question 2

Which of the following statements concerning the Periodic Table published by the Russian chemist D. Mendeleev in 1869 is **incorrect**?

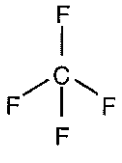
Mendeleev

A. related the chemical properties of elements in groups to their electron shell configuration.
B. left gaps in his table where no element was known to fit and he predicted properties of these undiscovered elements.
C. arranged elements in vertical groups based on their chemical properties.
D. arranged elements in rows in order of increasing atomic mass.

Question 3

For which of the following molecular substances would hydrogen bonding be possible?

A.



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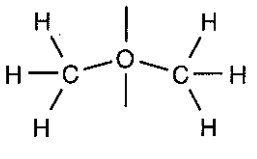

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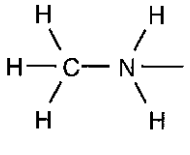
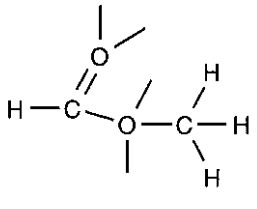
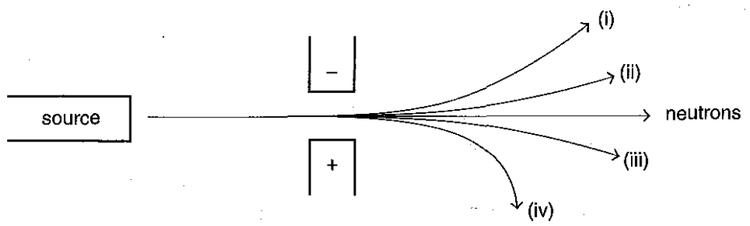


D.



Question 4

A beam of neutrons is not deflected in an electric field, as shown in the diagram below.



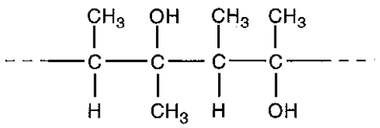
Which of the following identifies how beams of protons, electrons and alpha particles (all travelling at the same speed) would be affected by the electric field?

	protons	electrons	alpha particles
A.	(ii)	(iv)	(i)
B.	(i)	(iv)	(ii)
C.	(iii)	(ii)	(iv)
D.	(iii)	(i)	(ii)

Question 5

Which one of the following polymers would be expected to have the highest boiling point, assuming that all polymer chains are the same length?

A.



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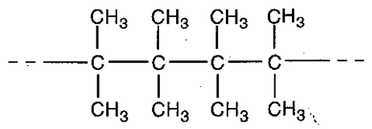
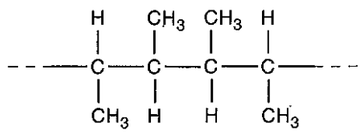
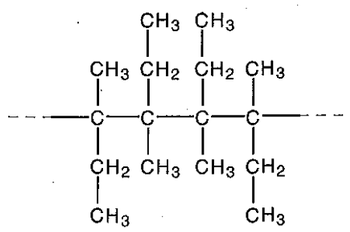


C.



D.



Question 6

Bromine and iodine are in the same group in the Periodic Table.
A bromine atom and an iodine atom would be expected to have

A. the same electronic configuration.
B. the same number of protons in their nuclei.
C. similar atomic mass.
D. similar chemical properties.

Question 7

Which of the following is a list of atoms in **increasing** order of electronegativity?

A. sodium, chlorine, bromine
B. sodium, bromine, chlorine
C. bromine, chlorine, sodium
D. chlorine, bromine, sodium

Question 8

Which of the molecules listed below has its shape **incorrectly** stated?

	Molecule	Shape
A.	OF_2	V-shaped
B.	PH_3	pyramidal
C.	CF_4	tetrahedral
D.	H_2S	linear

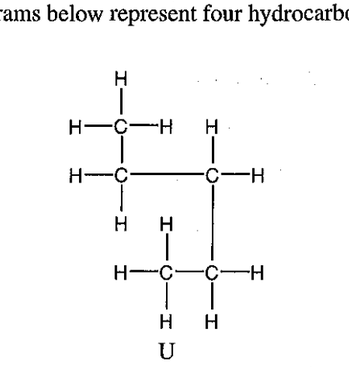
Question 9

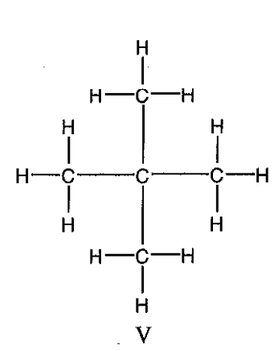
Which of the following conducts electricity by the movement of ions?

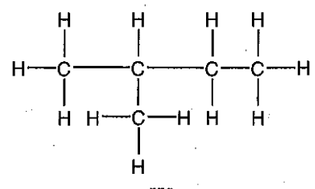
A. molten magnesium oxide
B. solid zinc
C. molten sulfur
D. solid calcium chloride

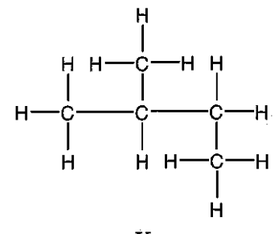
Question 10

The diagrams below represent four hydrocarbons.


U


V


W


X

The two diagrams which represent the same hydrocarbon are

A. U and W.
B. U and V.
C. V and X.
D. W and X.

Question 11

An atom of an element weighs 4.49×10^{-23} g. The element is most likely to be

A. boron (B). **B.** cobalt (Co). **C.** aluminium (Al). **D.** hydrogen (H).

Question 12

Which of the following contains the largest number of oxygen atoms?

A. 1 mole of oxygen, O_2
B. 6×10^{23} atoms of oxygen
C. 24 g of oxygen, O_2
D. 24 g of ozone, O_3

Question 13

A mixture of sodium chloride and sodium sulfate contains 0.4 mol of chloride ion and 0.3 mol of sulfate ion. The amount (in mol) of sodium in the mixture is

A. 0.3 **B.** 0.4 **C.** 0.7 **D.** 1.0

Question 14

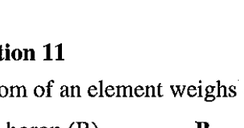
Which of the following statements regarding d subshells is **not** correct?

A. The energy of the d subshell in any shell is greater than the energy of the p subshell in that shell.
B. There are five orbitals in the d subshell.
C. Each orbital in the d subshell holds a maximum of two electrons.
D. The d subshell of a shell always fills before the s subshell of the next highest shell.

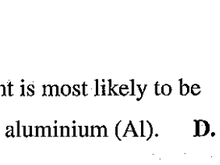
Question 15

An organic compound has the formula C_3H_6O. Which of the following could be its structural formula?

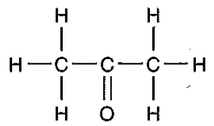
A.



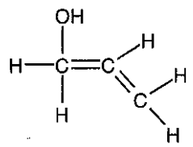
B.



C.



D.



Question 16

The first ionisation energy of an element is the energy needed to remove the most loosely bound electron from an atom of the element. The first ionisation energy of sodium is 502 kJ mol^{-1}.

This is lower than the first ionisation energy of magnesium (744 kJ mol^{-1}) because

A. the outermost electron in magnesium is further from the nucleus than the outermost electron in sodium.
B. the nuclear charge of magnesium is greater than the nuclear charge of sodium.
C. the electron removed from magnesium comes from a p subshell, while the electron removed from sodium comes from an s subshell.
D. magnesium has three isotopes, while sodium has only one.

Question 17

Which of the following lists the order in which the three subatomic particles were discovered?

A. proton, electron, neutron
B. electron, proton, neutron
C. neutron, proton, electron
D. electron, neutron, proton

Question 18

Which of the following comparisons between ethane (C_2H_6) and ethene (C_2H_4) is **incorrect**?

A. Only ethene, not ethane, may act as a monomer in the formation of addition polymers.
B. The carbon–carbon bond length is longer in ethane than in ethene.
C. Both have the same chemical properties because they are both hydrocarbons.
D. Both have a molecular formula which is different from their empirical formula.

Question 19

Which of the lists below shows the liquids in order of **increasing** surface tension?

A. mercury, water, ethanol, pentane
B. pentane, ethanol, water, mercury
C. water, pentane, ethanol, mercury
D. mercury, ethanol, pentane, water

Question 20

The surface energy of a solid reflects the strength of cohesive forces in the solid. Candle wax, iron and diamond have surface energies of 50 mJ m^{-2}, 1360 mJ m^{-2} and 9820 mJ m^{-2} respectively.

Which of the following best represents the major type of cohesive forces in each solid?

	candle wax	**iron**	**diamond**
A.	dispersion forces	ionic bonds	metallic bonds
B.	ionic bonds	metallic bonds	dispersion forces
C.	dispersion forces	metallic bonds	covalent bonds
D.	covalent bonds	dispersion forces	ionic bonds

Section B – Short-answer questions

Instructions for Section B

Answer all questions in the spaces provided in this book. Do **not** respond to a question anywhere other than in the space immediately following the question. Where lines are provided under a question, the number of lines is intended to be more than sufficient for your response.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example $H_2(g)$; NaCl(s).

Question 1

The table below contains incomplete information about two ions, A and B.

Ion	Mass number	Atomic number	Number of neutrons	Number of electrons	Valency of ion
A	56		30		+2
B		17	18	18	

a. Provide the missing numbers to complete the table.

2 marks

b. Write the electronic configuration, using subshell notation, of an **atom** of element A.

1 mark

c. Atoms of an element are most stable when found in their **ground state**.

i. Explain what is meant by the 'ground state' of an atom.

ii. Write a possible electronic configuration for an **atom** of **element B** which is in an **excited** state.

1 + 1 = 2 marks

d. Give the formula for the compound formed between ions of A and B.

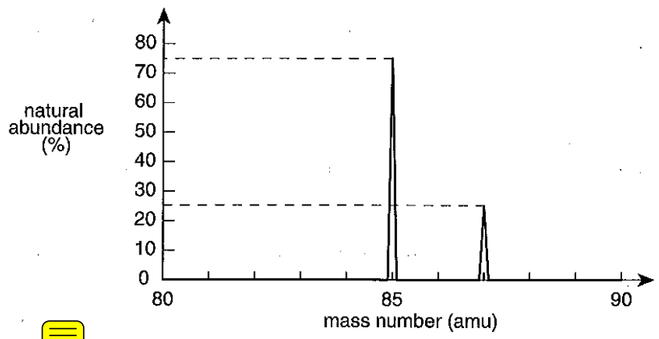
1 mark
Total 6 marks

Question 2

a. In 1910 the English chemist F. Soddy, working with radioactive substances, found that some elements had identical chemical properties but different relative masses. He called such elements isotopes.

i. Why do isotopes of elements have identical chemical properties?

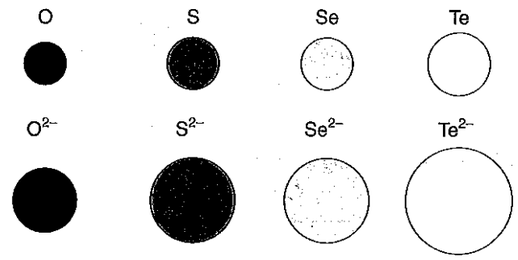
ii. The mass spectrum of an element containing two isotopes is shown below.



Using the data above, calculate the relative atomic mass of the element (to one decimal place).

2 + 2 = 4 marks

b. The atomic and ionic sizes for the Group 16 elements are shown below.



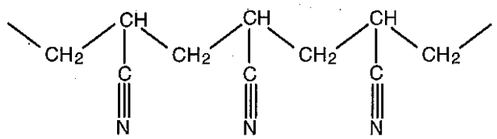
i. Explain why atomic size increases down the group.

ii. Explain why the negative ion is larger than the neutral atom of the same element.

1 + 2 = 3 marks
Total 7 marks

Question 3

The molecule acrylonitrile can be polymerised to give a synthetic fibre with properties similar to wool. A section of the polymer chain of polyacrylonitrile is shown below.

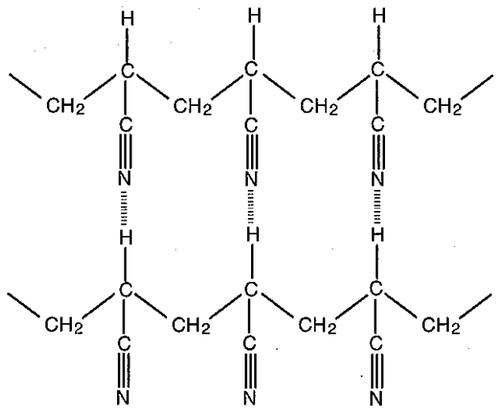


a. **i.** Draw a structural diagram for the acrylonitrile monomer used to form this polymer.

ii. Name the type of polymerisation involved in forming this polymer.

_____

iii. The small cyano (C≡N) group permits close packing of chains and interchain bonding as shown below.



Name the type of interchain bonding shown.

_____

1 + 1 + 1 = 3 marks

b. **i.** Write the empirical formula of polyacrylonitrile.

_____

ii. The molar mass of a particular polyacrylonitrile is 5.04×10^4 g mol^{-1}. How many acrylonitrile monomers were polymerised to produce each polyacrylonitrile molecule?

_____

_____

1 + 1 = 2 marks
Total 5 marks

Question 4

The following article concerns research into 'smart metals'.

> Metals have long fascinated humans because of the range of properties they demonstrate. They can be **pounded, shaped and bent**. They are good conductors of heat and electricity. Some also have the ability to take on different shapes depending on the temperature to which they are exposed. These metals are **alloys** that appear to be able to 'remember' the shapes they originally had at various temperatures.
>
> One example is the alloy used in teeth braces. At room temperature the alloy is flexible, allowing easy attachment to the teeth. As the alloy reaches mouth temperature, it becomes less flexible, 'remembers' its original shape and tightens to pull on the teeth.

a. In terms of their structure, explain how metals are able to be 'pounded, shaped and bent', i.e. metals are malleable. Include a diagram in your answer.

_____

_____

_____

_____

3 marks

b. The properties of metals enable them to be used in a wide range of devices. State **one** property of each metal which best explains their use in each of the following devices.

i. tungsten in electric light filaments

_____

ii. mercury in thermometers

_____

1 + 1 = 2 marks

c. **i.** What is meant by the term 'alloy'?

_____

_____

ii. The 'smart metals' described in the passage show one way in which the properties of an alloy may differ from those of the parent metals. Describe **one** other difference in properties between alloys and their parent metals.

_____

1 + 1 = 2 marks
Total 7 marks

Question 5

a. Complete the table below by providing the formula and type of structure of each solid substance.

Name of substance	Formula of substance	Structural type (molecular, covalent network lattice, layer lattice, ionic lattice, metallic lattice)
copper(II) hydroxide		
ammonia		
diamond		

6 marks

b. The two organic compounds whose names, formulas and boiling points are shown below have a similar molecular mass.

Methanal	Methanol
H_2CO	CH_3OH
–21°C	65°C

i. Draw valence structures for molecules of each of the two compounds, including all bonding and non-bonding electron pairs.

H_2CO	CH_3OH

ii. In terms of structure and bonding, account for the difference in boiling point of the two compounds.

2 + 2 = 4 marks
Total 10 marks

Question 6

Plants need a continual supply of nitrogen but they cannot use atmospheric nitrogen (N_2) directly. N_2 must first be converted to a soluble form which plants can absorb, i.e. NO_3^- or NH_4^+.

a. An industrial method for this conversion involves the production of nitrogen-containing fertilisers. A good fertiliser has a high percentage of nitrogen by mass. Two possible fertilisers are ammonium chloride, NH_4Cl and sodium nitrate $NaNO_3$.
Which of these compounds contains the highest percentage by mass of nitrogen? Show your working.

2 marks

b. A particular fertiliser has the percentage composition shown in the table below.

Element	Percentage by mass
nitrogen	35.0
hydrogen	5.00
oxygen	60.0

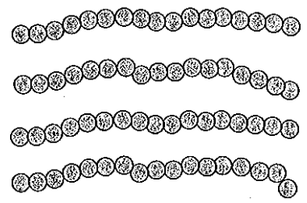
i. Determine the empirical formula of this fertiliser.

ii. The fertiliser is known to be an ionic compound. Suggest a likely formula for the fertiliser.

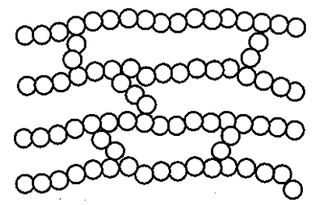
2 + 1 = 3 marks
Total 5 marks

Question 7

a. The diagrams below are a schematic representation of two polymer types.



polymer A



polymer B

Complete the table below by identifying the type of polymer found in each of the plastics listed.

Plastic	Use of plastic	Type of polymer (A or B)
phenol-methanal	frying-pan handles	
nylon 6,6	drip-dry clothing	
polypropene	ice-cream containers	

3 marks

b. **i.** Classify polymer B as thermoplastic or thermosetting.

ii. Briefly describe a simple laboratory procedure to distinguish a thermoplastic polymer from a thermosetting polymer.

1 + 1 = 2 marks
Total 5 marks

Practice Exam 2

Section A – Multiple-choice questions

Instructions for Section A

Answer all questions. Circle the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Question 1

In which of the following molecules is the hydrocarbon chain unsaturated?

A. $C_6H_{13}I$ **B.** C_3H_5Br **C.** $C_8H_{17}Cl$ **D.** $C_4H_9NH_2$

Question 2

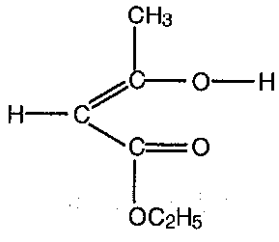
Which of the following properties would be expected to show a decreasing trend moving down the elements of a group in the Periodic Table?

A. electronegativity
B. number of occupied electron shells
C. number of outer-shell electrons
D. metallic character

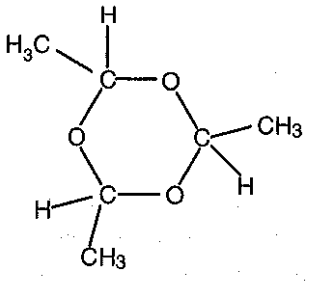
Question 3

Which of the following compounds has an empirical formula of C_3H_3O?

A.



B.



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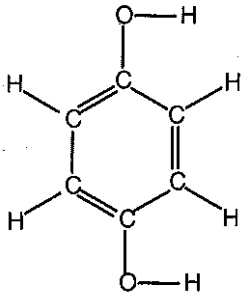
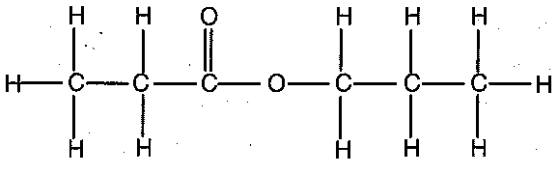
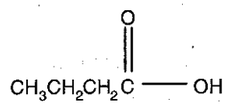


D.



Question 4

The molecular structure of a substance is represented in the diagram below.



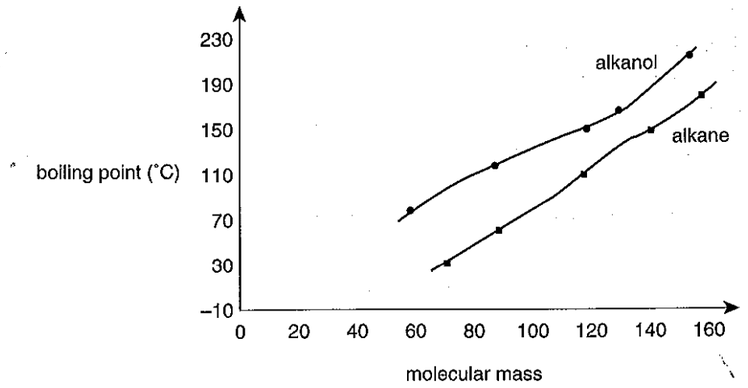
Which of the following statements regarding this substance is **incorrect**?

A. Its empirical formula is C_2H_4O.
B. There are four non-bonding electron pairs in the molecule.
C. Its molecules are non-polar.
D. Hydrogen bonding would occur between molecules of this substance.

Question 5

Alkanols are a homologous series of organic compounds which contain an —OH group in their structure.

The graph below shows the variation of boiling points of straight-chain alkanes and alkanols against their molecular mass.



When compared with hydrocarbons of similar molecular mass, alkanols have much higher boiling points. Which of the following accounts for these higher boiling points of alkanols?

A. Dispersion forces between alkanol molecules are stronger than dispersion forces between alkane molecules.
B. Covalent bonds between O–H are stronger than covalent bonds between C–H.
C. Ionic bonds occur in alkanols while only dispersion forces occur in alkanes.
D. Hydrogen bonds occur between alkanol molecules.

Question 6

Which quantity of nickel (Ni) has the smallest mass?

A. 6.02×10^{22} atoms **B.** 0.5 mol **C.** 17.6 g **D.** 3.01×10^{23} Ni^{2+} ions

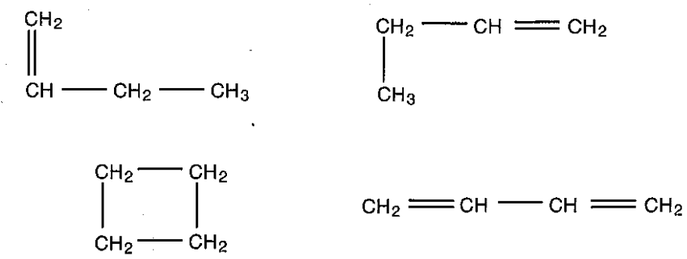
Question 7

The structure and bonding in diamond at room temperature and pressure is best described as

A. a layer of carbon atoms with weak dispersion forces between layers.
B. a network lattice of diatomic molecules of carbon.
C. a network of carbon ions attracted to delocalised electrons.
D. a network of carbon atoms held together by covalent bonds.

Question 8

Consider the following structures.

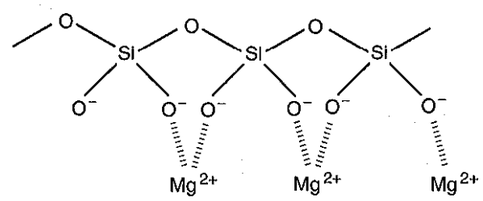


How many structural isomers of C_4H_8 are represented?

A. 1 **B.** 2 **C.** 3 **D.** 4

Question 9

The diagram below shows a simplified structure for asbestos.



The bonding in asbestos is

A. purely covalent. **B.** purely ionic.
C. both covalent and ionic. **D.** neither covalent nor ionic.

Question 10

Butane (C_4H_{10}) is used as the fuel in disposable cigarette lighters.

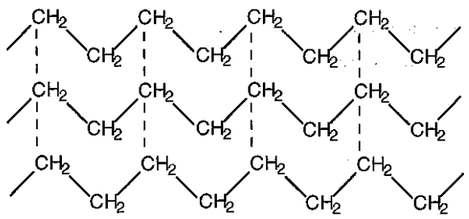
Which of the following statements concerning butane is **incorrect**?

A. 3.0 g of butane contains 2.5 g of carbon.
B. 2.0 g of butane contains 2.1×10^{23} atoms of hydrogen.
C. 0.5 mole of butane contains 4.2×10^{24} atoms.
D. 1 molecule of butane has a mass of 58 g.

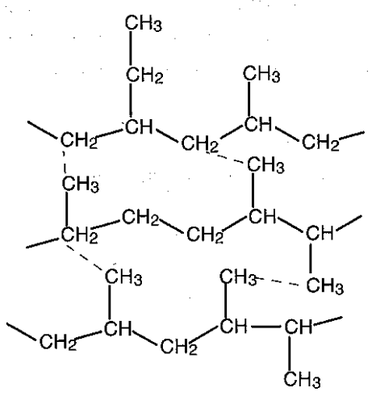
Question 11

The diagrams below represent four polymer types used in the production of plastics. Which plastic would be most suitable for use as a saucepan handle?

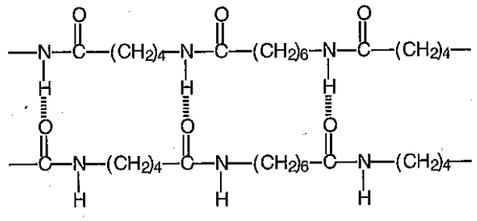
A.



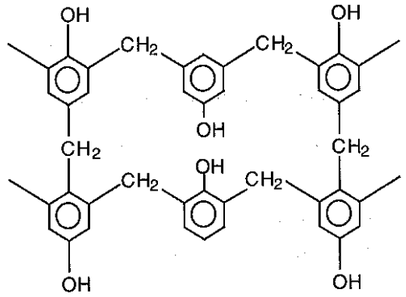
B.



C.



D.



Question 12

Which of the following compounds contains the highest percentage by mass of calcium?

A. $CaCO_3$ ($M = 100.1$ g mol^{-1})
B. CaC_2O_4 ($M = 128.1$ g mol^{-1})
C. $CaSO_4$ ($M = 136.2$ g mol^{-1})
D. $CaCl_2$ ($M = 111.1$ g mol^{-1})

Question 13

How many atoms of oxygen are there in 130 g of Na_2CrO_4?

A. 4.8×10^{23} **B.** 1.9×10^{24} **C.** 3.0×10^{24} **D.** 3.4×10^{24}

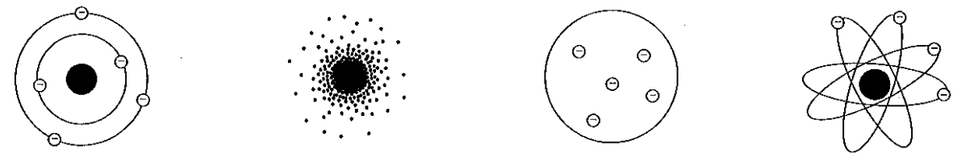
Question 14

Alchemists were early chemists who sought (among other things) to convert cheap metals into gold. They were unsuccessful in this aim chiefly because

A. they lacked the necessary chemicals.
B. their heat source did not produce sufficiently high temperatures.
C. chemical reactions cannot convert one element into another.
D. they used the wrong metal as the reactant.

Question 15

The sketches below show four models of the atom.



I II III IV

Which of the following correctly links a model and the scientist most closely associated with it?

A. Rutherford – III
B. Bohr – I
C. Thomson – II
D. Dalton – IV

Question 16

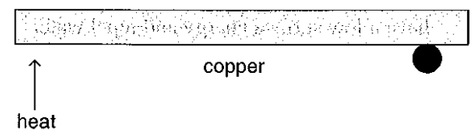
The particle shown as $^{31}_{15}X^{3-}$ contains

	protons	electrons	neutrons
A.	12	15	31
B.	15	12	16
C.	15	18	16
D.	18	15	31

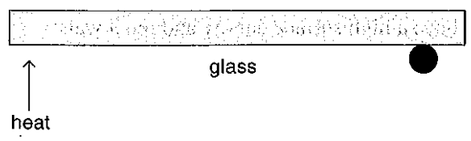
Question 17

The diagram shows metal bearings attached by wax to the ends of four rods of the same diameter and length, but different material. The rods are heated equally at their other ends. The metal bearings will fall off when the wax melts. Which rod will be the first to lose its metal bearing?

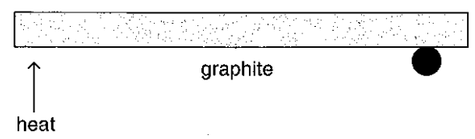
A.



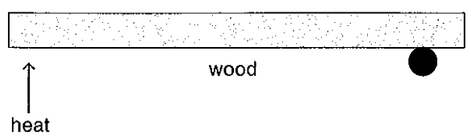
B.



C.



D.



Question 18

The following table shows the number of electrons for atoms of four different elements.

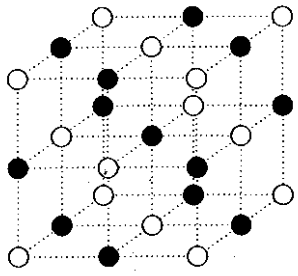
Element	Electrons
P	12
Q	8
R	17
S	19

The correct formula of a compound formed from two of these elements is

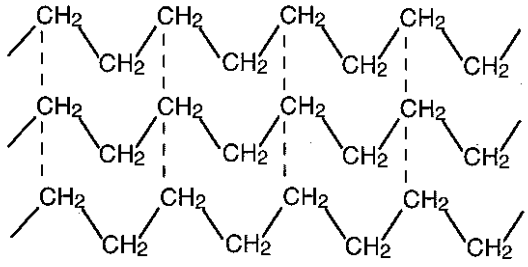
A. S_2R **B.** PR_2 **C.** P_2Q **D.** SQ

Question 19

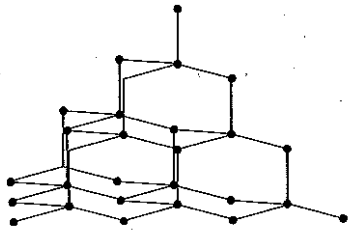
The diagrams below are representations of the bonding and structure of three different substances.



I



II



III

Which list shows the expected surface energies of the substances in decreasing order?

A. III, II, I **B.** II, I, III **C.** II, III, I **D.** III, I, II

Question 20

A hydrophilic surface would be expected to

A. have a high surface energy and attract water.
B. have a low surface energy and attract water.
C. have a high surface energy and repel water.
D. have a low surface energy and repel water.

Question 2

The table below lists the properties of several substances, identified only by the letters K–P (not their correct atomic symbols).

Substance	m.p. (°C)	b.p. (°C)	Density at 25°C (g mL^{-1})	Conductivity when solid	Conductivity when molten
K	–7	58	3.1	non-conductor	non-conductor
L	–38	357	13.6	conductor	conductor
M	29	690	1.5	conductor	conductor
N	–220	–188	–	non-conductor	non-conductor
O	1083	2600	9.0	conductor	conductor
P	801	1413	2.2	non-conductor	conductor

a. At 40°C, identify one substance from K–P which consists of particles which are

i. closely packed in a fixed pattern.

_____

ii. widely spaced.

_____

iii. oppositely charged ions.

_____

1 + 1 + 1 = 3 marks

b. Substances L, M, O and P all conduct electricity in at least one state. Which of these substances would be most suitable for use as wiring in electrical circuits? Explain your choice.

_____

_____

_____

_____

_____

2 marks

c. **i.** An alloy is formed by combining M and O. If this alloy were heated and then cooled rapidly, state how its properties would be altered.

_____

ii. Explain why the changes described in **i.** occurred.

_____

_____

_____

_____

1 + 2 = 3 marks
Total 8 marks

Question 7

a. Mercury has a surface energy of 480 mJ m^{-2}, while for glass the value is around 290 mJ m^{-2}.

i. What is meant by the term 'surface energy'?

_____

_____

ii. Explain why the surface energy of mercury is greater than that of glass.

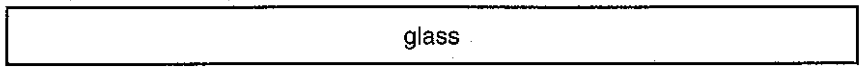
_____

_____

_____

1 + 1 = 2 marks

b. **i.** On the diagram below, sketch the expected appearance of mercury on a glass surface.



mercury on a glass surface

ii. Explain why mercury has the appearance shown in your sketch.

_____

_____

_____

_____

1 + 2 = 3 marks
Total 5 marks

Practice Exam 3

Section A – Multiple-choice questions

Instructions for Section A

Answer all questions. Circle the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Question 1

Which one of the following is a homologous series?

A. CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$ **B.** CH_3Cl, C_2H_5Cl, C_3H_7Cl, C_4H_9Cl

C. CH_3Cl, CH_3CH_2Br, $CH_3(CH_2)_2I$, $CH_3(CH_2)_3F$ **D.** C_2H_5Br, $C_2H_4Br_2$, $C_2H_3Br_3$, $C_2H_2Br_4$

Question 2

Which of the following pairs of substances are both covalent network solids?

A. silicon carbide and diamond **B.** paraffin wax and graphite

C. copper and polyethene **D.** sodium chloride and glass

Question 3

Which one of the following statements concerning the compounds $CH_3CH_2CH_2CH_3$ and $(CH_3)_3CH$ is **incorrect**?

A. They are members of different homologous series.

B. They are both saturated hydrocarbons.

C. They are structural isomers.

D. They have different physical properties.

Question 4

In the modern Periodic Table, elements are arranged in order of increasing

A. number of neutrons. **B.** electronegativity.

C. number of outer shell electrons. **D.** atomic number.

Question 5

Which of the following contains the greatest number of mole of nitrogen atoms?

A. 20.5 g of N_2

B. 21.7 g of N_2H_4

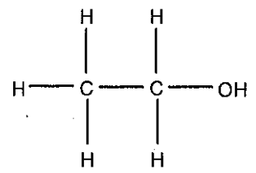
C. 6.02×10^{22} molecules of NO_2

D. 3.01×10^{24} atoms of N

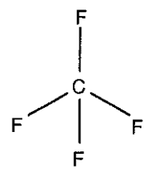
Question 6

Which of the following molecules could undergo addition polymerisation?

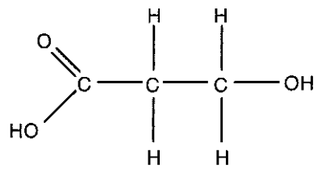
A.



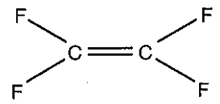
B.



C.



D.



Question 7

Listed below are a number of statements (I–IV) concerning a set of elements.

I Their ionisation energy increases with increasing atomic number.

II They have the same number of occupied electron shells.

III They have physical properties which change with increasing atomic number.

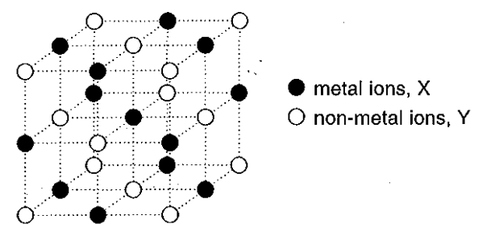
IV They have the same number of electrons in the outermost shell.

Which of these statements apply to elements in the same group of the Periodic Table?

A. II, III and IV only **B.** I, III and IV only **C.** III and IV only **D.** I and III only

Question 8

The diagram below shows part of the structure of an ionic compound.



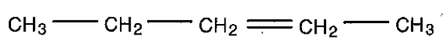
The formula for the compound is

A. XY_2 **B.** X_2Y **C.** XY **D.** $X_{13}Y_{14}$

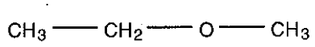
Question 9

Which one of the following organic structural formulas is correct?

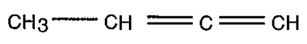
A.



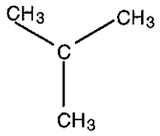
B.



C.

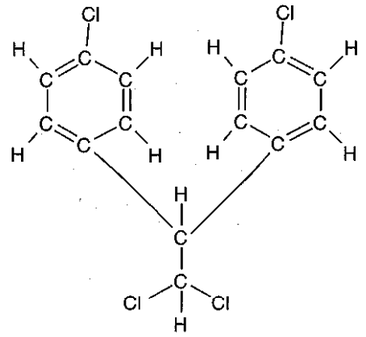


D.



Question 10

The empirical formula of the molecule shown below is



A. C_3H_2Cl **B.** $C_7H_5Cl_2$ **C.** $C_{12}H_8Cl_4$ **D.** $C_{14}H_{10}Cl_4$

Question 11

How many atoms of oxygen are there in 882 g of $K_2Cr_2O_7$?

A. 6.02×10^{23} **B.** 1.81×10^{24} **C.** 1.26×10^{25} **D.** 4.21×10^{24}

Question 12

Most metallic materials we use are alloys obtained by mixing one metal with another element, usually a metal.

Compared to the parent metal, the alloy often

A. is more resistant to corrosion.
B. is more ductile.
C. is more lustrous.
D. is a better electrical conductor.

Questions 13 to 16 refer to the following information.

The table below contains incomplete information about two **ions**: X and Y.

Ion	Mass number	Atomic number	Number of neutrons	Number of electrons	Valency of ion
X	59	27	*k*	*l*	+2
Y	39	*m*	20	18	*n*

Question 13

Which of the following shows the values of the missing numbers (*k*–*n*) in the table above?

	k	*l*	*m*	*n*
A.	59	25	19	–1
B.	32	29	19	+1
C.	32	27	39	–1
D.	32	25	19	+1

Question 14

The electronic configuration of an **atom** of X is

A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$.
B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$.
C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$.
D. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$.

Question 15

Element Y belongs to which group and period in the Periodic Table?

A. Group 1, Period 3
B. Group 18, Period 3
C. Group 1, Period 4
D. Transition metal, Period 5

Question 16

Which of the following properties is **not** shared by elements X and Y?

A. malleability
B. formation of coloured compounds
C. good electrical conductivity
D. melting point above room temperature

Question 17

Which of the following bonds requires the **least** energy to break?

A. the intermolecular bond between two bromine molecules in a sample of liquid bromine
B. the intramolecular bond between nitrogen atoms in nitrogen gas
C. the bond between two carbon atoms in a solid diamond lattice
D. the bond between two lead ions in a sample of solid lead

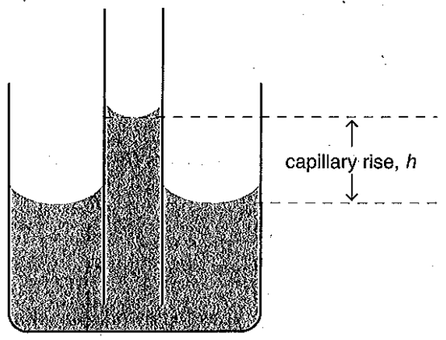
Question 18

In the formula C_xH_y, the value of *y* for an alkene containing five carbon atoms is

A. 5 **B.** 8 **C.** 10 **D.** 12

Question 19

The diagram below represents a liquid rising up a narrow glass capillary. The example shown is a liquid that wets glass. The height to which the water rises in the capillary is given by *h*.



water in a glass capillary

Provided a liquid wets the material of a capillary, which of the following combination of conditions would result in a maximum value of *h*?

A liquid with

A. low surface tension in a capillary tube of large diameter.

B. low surface tension in a capillary tube of small diameter.

C. high surface tension in a capillary tube of large diameter.

D. high surface tension in a capillary tube of small diameter.

Question 20

The surface energy of a substance is defined as

A. the strength of the bonds that hold a substance in a given shape.

B. the energy required for the formation of a new unit area of surface.

C. the energy released when the surface area of a substance is increased by one unit area.

D. the extent to which the substance is wet by water.

Section B – Short-answer questions

Instructions for Section B

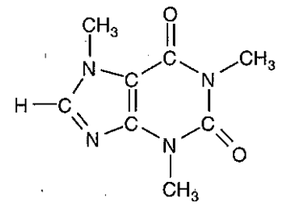
Answer all questions in the spaces provided in this book. Do **not** respond to a question anywhere other than in the space immediately following the question. Where lines are provided under a question, the number of lines is intended to be more than sufficient for your response.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example $H_2(g)$; NaCl(s).

Question 1

Caffeine is a stimulant found in coffee, tea and many soft drinks. Caffeine has the following structural formula.



$M = 194 \text{ g mol}^{-1}$

a. **i.** What is the empirical formula for caffeine?

_____

ii. What is the percentage by mass of nitrogen in caffeine?

_____

_____

1 + 1 = 2 marks

b. Determine the mass (in g) of the one molecule of caffeine.

_____

_____

1 mark

c. A cup of coffee contains approximately 110 mg of caffeine.

i. Calculate the number of moles of caffeine in one cup of coffee.

_____

_____

ii. Calculate the number of carbon atoms in 110 mg of caffeine.

_____

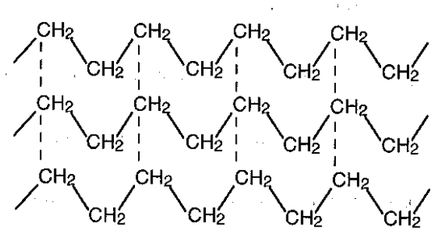
_____

1 + 2 = 3 marks

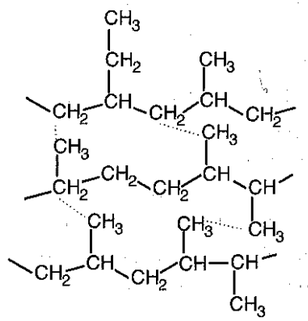
Total 6 marks

Question 2

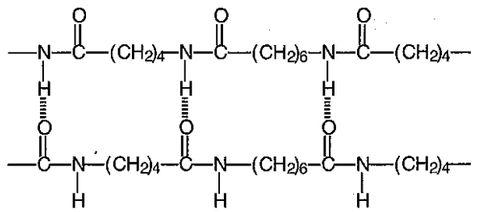
The diagrams below represent four polymer types used in the production of plastics.



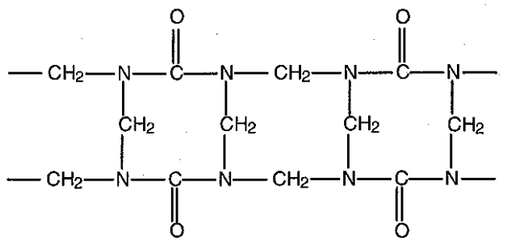
I



II



III



IV

a. I is described as a thermosoftening plastic. What is meant by the term 'thermosoftening'?

_____

_____

1 mark

b. Which plastic (I, II, III or IV) would you expect to char when heated? Explain your choice.

_____

_____

_____

2 marks

c. Plastic I melts at 135°C. Plastic II melts at 105°C. In terms of the structure of these plastics, how can this difference in melting points be explained?

_____

_____

1 mark

d. Which plastic (I, II, III or IV) would be most suitable for use in making kitchen bench tops? Explain your choice.

_____

_____

2 marks

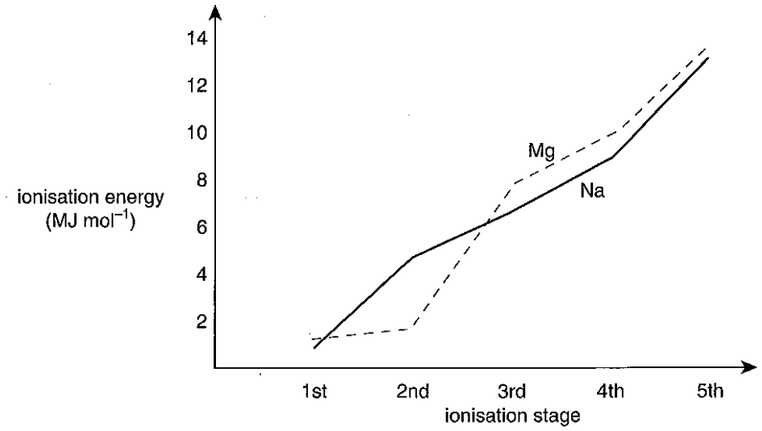
Total 6 marks

Question 3

a. Ionisation energy is defined as the minimum amount of energy required to remove an electron from an atom or ion in the gaseous state. Successive ionisation energies for sodium and magnesium are shown in the table below.

Element	Ionisation energy (MJ mol^{-1})				
	1st	2nd	3rd	4th	5th
sodium	0.5	4.6	6.9	9.5	13.4
magnesium	0.7	1.5	7.7	10.5	13.6

A graph of the ionisation energies of sodium and magnesium is shown on the axes below.



Although the first five ionisation energies for sodium and magnesium show a similar range, the pattern of increase is slightly different for each element.

Explain why the pattern of increase in ionisation energy is different for sodium and magnesium.

_____

_____

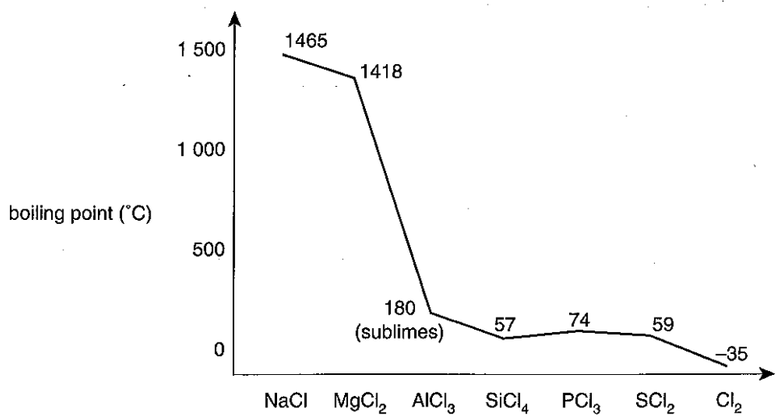
_____

_____

_____

4 marks

b. The graph below illustrates the trends in boiling points of chlorides of elements in the third period.



Account for the difference in boiling points of $MgCl_2$ and Cl_2.

2 marks
Total 6 marks

Question 4

The relative atomic mass of gallium is 69.7. Naturally occurring gallium consists of two isotopes. One isotope is 39.5% abundant and its relative isotopic mass is 70.8.

a. What is the percentage abundance of the second isotope?

1 mark

b. Calculate the relative isotopic mass of the second isotope.

2 marks

c. Use the ${}^{A}_{Z}X^{C}$ notation to represent the ion formed when an atom of the lighter isotope of gallium loses three electrons.

1 mark
Total 4 marks

Question 5

a. The basic assumptions of the English chemist J. Dalton's atomic theory in his book *New System of Chemical Philosophy*, published in 1808, can be summarised in the following statements.

1. All matter is composed of atoms, which are indivisible.
2. All the atoms of a given element are alike in mass and in all other respects.
3. The atoms of different elements are of different masses.
4. Atoms are indestructible and preserve their identities in all reactions.

i. Statement 2 is not correct. Not all atoms of a given element have the same mass. Explain carefully how atoms can belong to the same element but have different mass.

ii. Choose one other statement (i.e. statement 1, 3 or 4) and discuss the accuracy or limitations of the statement.

2 + 2 = 4 marks

b. In 1911, the New Zealand physicist E. Rutherford supervised an experiment which involved firing small, positively charged particles at a piece of gold foil. As a result of this experiment, Rutherford proposed a new model for the atom.

i. Briefly describe the model proposed by Rutherford. Include a diagram with your description.

ii. State one way in which our current model of the atom differs from Rutherford's model.

2 + 1 = 3 marks
Total 7 marks

Question 6

The table below lists the boiling points of four hydrides of Group 15 elements and the electronegativity of each Group 15 element.

Substance	NH_3	PH_3	AsH_3	SbH_3
Boiling point (°C)	–33	–88	–63	–17
Electronegativity of the Group 15 element	3.0	2.1	2.0	1.9

(electronegativity of H = 2.1)

a. **i.** Draw a diagram to represent the structural formula of the ammonia (NH_3) molecule.

ii. Name the shape of the ammonia molecule.

_____

iii. Is a molecule of ammonia polar or non-polar?

_____

1 + 1 + 1 = 3 marks

b. **i.** The phosphorus–hydrogen bond in phosphine is a strong covalent bond. Explain why the boiling point of phosphine is very low.

_____

_____

_____

_____

ii. There is an increase in the boiling point of AsH_3 and SbH_3 compared to PH_3. Name the type of bonding which accounts for this trend.

_____

2 + 1 = 3 marks
Total 6 marks

Question 7

a. The properties of a substance are related to its structure. The table below shows melting points and conductivity of four substances.

Substance	Melting point (°C)	Electrical conductivity		Classification	Example	Use
		Melt	Solid			
1	> 3550	negligible	negligible			
2	–182	negligible	negligible			
3	801	high	very low			
4	1080	high	high			

i. On the basis of the properties in the table, classify each substance (1–4) as ionic, metallic, molecular, covalent network or covalent layer. Add this information to the table.

ii. Select an example of each substance in the table (1–4) from the list below. Add this information to the table.

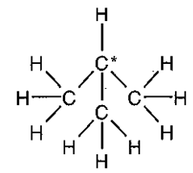
copper, diamond, graphite, water, mercury, methane, sodium chloride

iii. Select one possible use for each substance in the table (1–4) from the list below. Add this information to the table.

lubricant, fuel, electrical wiring, glass-cutting tool, food preservative

2 + 2 + 2 = 6 marks

b. In a molecule of 2-methylpropane (shown below), the maximum number of carbon atoms covalently bonded to any one C* atom is 3.



For each of the substances named below, state the maximum number of carbon atoms covalently bonded to any one carbon atom within the structure.

i. but-2-ene

_____

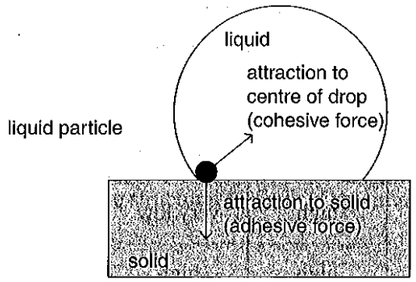
ii. graphite

_____

1 + 1 = 2 marks
Total 8 marks

Question 8

The forces acting on a liquid particle in contact with a solid surface determine the extent to which the liquid wets the solid.



a. A drop of mercury is placed on a glass surface.

i. Which forces acting on the drop of mercury are stronger: cohesive or adhesive?

_____

ii. Name the major bond type responsible for the cohesive force.

_____

iii. Name the major bond type responsible for the adhesive force.

_____

1 + 1 + 1 = 3 marks

b. When an aqueous solution of pesticide is sprayed on a waxy leaf, droplets form.

i. What could be added to the aqueous solution to enable the solution to wet the leaf, rather than form droplets?

_____

ii. With the aid of a diagram, explain how the addition in **i.** enables wetting of the leaf to occur.

_____

_____

_____

iii. Why is it desirable that wetting occurs?

_____

_____

1 + 2 + 1 = 4 marks
Total 7 marks

Solutions

Practice Exam 1

Section A – Multiple-choice questions

Question 1 **A**

Number the carbons from the right-hand end. Methyl groups (CH_3) are attached to carbons 2 and 4. The longest continuous carbon chain has 5 carbons, hence it is pentane. Octane is not the systematic name – the molecule shown is an isomer of octane.

Question 2 **A**

Electron shells were not proposed until the early 1900s. Mendeleev did not therefore relate properties to electron shell configuration. Therefore, **A** is incorrect. Statements **B**, **C** and **D** are correct.

Question 3 **C**

Hydrogen bonding occurs between molecules which contain hydrogen bonded to F, O or N. The molecule in **C** is the only one which fits this criterion.

Question 4 **B**

Protons and alpha particles ($^4_2He^{2+}$) will be deflected toward the negative electrode. Therefore **C** and **D** are incorrect. Protons will be deflected more than alpha particles because they are lighter. Therefore, **B** is correct.

Question 5 **A**

Polymer **A** will have hydrogen bonding between polymer chains. Polymers **B**, **C** and **D** will have dispersion forces only. Hydrogen bonds are stronger, leading to a higher boiling point. The branching in polymer **D** would lead to a lower boiling point.

Question 6 **D**

Elements in the same group have the same outer-shell configuration, leading to similar chemical properties. Elements in a group do not have the same electronic configuration or atomic number or atomic mass.

Question 7 **B**

Metal have low electronegativity, hence sodium is first. Electronegativity decreases down a group, so bromine before chlorine.

Question 8 **D**

H_2S is a V-shaped molecule like water. There are four electron pairs around the S, two bonding and two non-bonding.

Question 9 **A**

MgO and $CaCl_2$ are ionic. Solid $CaCl_2$ has fixed ions and therefore does not conduct. S is molecular and does not conduct in either solid or molten states. Zn is a metal which conducts by movement of electrons.

Question 10 **D**

W and X both represent 2-methylbutane.

Question 11 **C**

6.02×10^{23} atoms of an element (1 mole) have a mass equal to the molar mass of the element. If 1 atom has a mass of 4.49×10^{-23} g then 6.02×10^{23} atoms have a mass of $4.49 \times 10^{-23} \times 6.02 \times 10^{23}$ g.

Therefore the molar mass is 27 g mol^{-1}. The RAM is 27. The element is therefore Al.

Question 12 **A**

A. 1 mole of O_2 = 2 mole of O atoms = 12×10^{23} atoms

B. 6×10^{23} atoms

C. 24 g of O_2 $= \frac{24}{32} = 0.75$ mole of O_2

$= 0.75 \times 2$ mole of O atoms $= 9 \times 10^{23}$ atoms

D. 24 g of O_3 $= \frac{24}{48} = 0.5$ mole of O_3

$= 0.5 \times 3$ mole of O atoms $= 9 \times 10^{23}$ atoms

$\therefore$ The largest number of atoms is 12×10^{23}.

Question 13 **D**

$$n_1(Na^+) = n(NaCl) = n(Cl^-) = 0.4 \text{ mol}$$

$$n_2(Na^+) = 2 \times n(Na_2SO_4) = 2 \times n(SO_4^{2-})$$

$$= 2 \times 0.3 = 0.6 \text{ mol}$$

$$\therefore n(Na^+)_{TOTAL} = n_1 + n_2 = 0.4 + 0.6 = 1.0 \text{ mol}$$

Question 14 **D**

The energy of subshells in any one shell is s < p < d. Therefore, **A** is a correct statement.

There are five orbitals in a d subshell. Therefore, **B** is correct.

Pauli's exclusion principle states that a maximum of two electrons per orbital applies to d subshells. Therefore, **C** is correct.

The 3d subshell fills after the 4s subshell. Therefore **D** is incorrect and so is the required response.

Question 15 **C**

A has too many hydrogen atoms. **B** has a hydrogen atom with two bonds, which is impossible. **D** has a carbon atom with five bonds, which is impossible. Hence **C** is the correct answer.

Question 16 **B**

Atomic radii decrease across a period, i.e. the radius of Mg is less than the radius of Na. Therefore, **A** is incorrect.
Electrons from both Na and Mg come from the s subshell. Therefore, **C** is incorrect.
The number of isotopes does not influence the ease with which an electron may be removed from an atom. Therefore, **D** is incorrect.
The greater nuclear charge in Mg (12 compared with 11 in Na) means that the outer-shell electron is held more tightly and hence is more difficult to remove.

Question 17 **B**

Thomson's gas discharge tube experiments revealed electrons and were carried out in the late 1800s. Protons were discovered in the early 1900s (although the existence of positive particles was suggested earlier). Chadwick confirmed the existence of neutrons in the 1930s.

Question 18 **C**

Ethene is more reactive than ethane, due to the presence of the reactive double bond. **C** is therefore an incorrect statement.
The statements in **A**, **B** and **D** are correct.

Question 19 **B**

Pentane: There are weak dispersion forces between molecules, so there is low surface tension.
Ethanol: There are some hydrogen bonds between molecules, so there is medium surface tension.
Water: There are hydrogen bonds between molecules, so there is high surface tension.
Mercury: There are metallic bonds between particles, so there is very high surface tension.

Question 20 **C**

Wax is a non-polar substance held together by dispersion forces.
Iron is metallic.
Diamond is a covalent network lattice.

Section B – Short-answer questions

Question 1

a.

Ion	Mass number	Atomic number	Number of neutrons	Number of electrons	Valency of ion
A	56	**26**	30	**24**	+2
B	**35**	17	18	18	**–1**

b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

c. **i.** An atom is said to be in its 'ground state' when its electrons are in the lowest possible energy state.

ii. $1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$
(or any other configuration in which electrons have been promoted from their 'ground state')

d. AB_2 ($FeCl_2$)

Question 2

a. **i.** Chemical properties are determined by electron configuration. Isotopes have the same number of electrons, hence the same electron configuration.

ii. RAM = $\sum$(RIM × abundance fraction)

$$= \left(85 \times \frac{75}{100}\right) + \left(87 \times \frac{25}{100}\right)$$

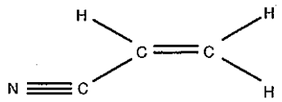
$$= 85.5$$

b. **i.** The number of electron shells increases down a group.

ii. In the negative ion, there is increased repulsion between added electrons in the outer shell of the ion.

Question 3

a. **i.**



ii. Addition

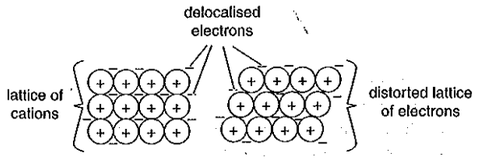
iii. Dipole–dipole (not hydrogen bonding since H is not covalently bonded to F, O or N).

b. **i.** C_3H_3N

ii. $N = \frac{5.04 \times 10^4}{53} = 951$

Question 4

a. Metals consist of a lattice of cations immersed in a sea of electrons. Strong electrostatic forces bind the cations and electrons together. When cations are moved, the flow of electrons allows a change of shape without disrupting the electrostatic forces, hence metals are malleable.



b. **i.** For example:
- high melting point
- ductile
- electrical conductor

ii. Liquid expands when heated.

c. **i.** A mixture of metals, or a metal/non-metal mix, which shows metallic properties.

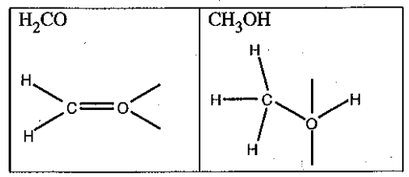
ii. For example:
- Alloys are less corrosive.
- Alloys are less malleable.
- Alloys are harder.
- Alloys may have lower melting points.

Question 5

a.

Name of substance	Formula of substance	Structural type
copper(II) hydroxide	$Cu(OH)_2$	**Ionic lattice**
ammonia	NH_3	**Molecular**
diamond	**C**	**Covalent network lattice**

b. **i.**



ii. Both are polar molecules and hence both have dipole–dipole intermolecular bonds. Methanol has hydrogen bonding between molecules. As this is stronger than dipole–dipole bonding, methanol's boiling point is much higher. Both substances have similar dispersion forces between molecules (due to similar molecular masses).

Question 6

a. NH_4Cl $\%N = \frac{M(N)}{M(NH_4Cl)} \times \frac{100}{1} = \frac{14.0}{53.5} \times \frac{100}{1}$

$$= 26.2\%$$

$NaNO_3$ $\%N = \frac{M(N)}{M(NaNO_3)} \times \frac{100}{1} = \frac{14.0}{85.0} \times \frac{100}{1}$

$$= 16.5\%$$

b. **i.**

N	:	H	:	O	
$\frac{35.0}{14.0}$	:	$\frac{5.00}{1.00}$	:	$\frac{60.0}{16.0}$	
2.5	:	5.0	:	3.75	
1	:	2	:	1.5	
2	:	4	:	3	$N_2H_4O_3$

ii. NH_4NO_3

Question 7

a. Linear polymers (A) produce plastics which are soft and melt when heated. These include polypropene and nylon.
Cross-linked polymers (B) produce plastics which are hard and do not soften when heated. Such plastics are used for frying-pan handles, and include phenol-methanal.

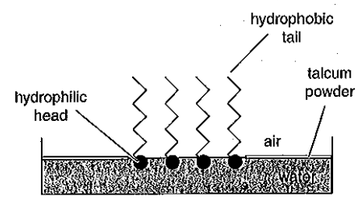
b. **i.** Thermosetting

ii. Take a very small piece of polymer in a pair of tongs and heat using a Bunsen burner in the fume cupboard. A thermoplastic polymer will melt or burn. A thermosetting polymer will not melt, it will char.

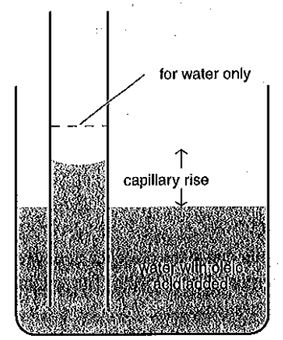
Question 8

a. Oleic acid has a hydrophobic (non-polar, water fearing) 'tail' ($C_{17}H_{33}$) and a hydrophilic (polar) 'head' (–COOH) which binds to polar water molecules.

b. The 'tails' point outwards from the water surface. The 'heads' point inwards.



c. **i.**



ii. The addition of the oleic acid reduces the surface tension of the water. With lower surface tension the 'pull' due to surface tension decreases, hence capillary rise decreases.

Practice Exam 2

Section A – Multiple-choice questions

Question 1 **B**

A saturated hydrocarbon chain will have the formula C_nH_{2n+1}, hence C_6H_{13} (**A**), C_8H_{17} (**C**) and C_4H_9 (**D**). C_3H_5 has the formula C_nH_{2n-1}, and so is unsaturated.

Question 2 **A**

Moving down a group, the number of shells increases (so it is not **B**), the number of outer-shell electrons is constant (so it is not **C**), and metallic character increases (so it is not **D**). Electronegativity decreases due to the increasing distance of the outer-shell electrons from the nucleus.

Question 3 **C**

A is $C_6H_{10}O_3$, **B** is $C_6H_{12}O_3$ (so C_2H_4O) and **D** is $C_6H_{12}O_2$ (so C_3H_6O).
C is $C_6H_6O_2$ (so C_3H_3O).

Question 4 **C**

The molecule is polar due to the presence of oxygen atoms and the lack of symmetry of the molecule. The statements in **A**, **B** and **D** are correct.

Question 5 **D**

Hydrogen bonding is stronger than dispersion forces, leading to higher boiling points. Similar molecular masses produce dispersion forces of similar strength (so it is not **A**). The intramolecular covalent bonds (OH and CH) do not influence the boiling point.

Question 6 **A**

$M(\text{Ni}) = 58.7 \text{ g mol}^{-1}$

A. 6.02×10^{22} atoms = 0.1 mol = (0.1×58.7) g = 5.87 g

B. 0.5 mol = (0.5×58.7) g = 29.4 g

C. 17.6 g

D. 3.01×10^{23} ions = 0.5 mol = (0.5×58.7) g = 29.4 g

Therefore, the smallest mass is 5.87 g.

Question 7 **D**

Diamond is a covalent network lattice with each carbon atom covalently bonded to four others.

Question 8 **B**

The top two structures are the same molecule (C_4H_8). The ring structure is also C_4H_8. The last structure is C_4H_6. Therefore there are two isomers shown.

Question 9 **C**

Si — O is a covalent bond, and O^- ||||||| Mg^{2+} is an ionic bond.

Question 10 **D**

A. $\%\text{C in } C_4H_{10} = \left(\frac{4 \times 12.0}{58}\right) \times \frac{100}{1}$

$\therefore m(\text{C})$ in 3.0 g of $C_4H_{10} = \frac{48}{58} \times 3.0 = 2.5$ g

B. $n(C_4H_{10}) = \frac{m}{M} = \frac{2.0}{58}$

$n(\text{H}) = 10 \times n(C_4H_{10}) = 10 \times \frac{2.0}{58}$

$N(\text{H}) = n \times N_A = 10 \times \frac{2.0}{58} \times 6.0 \times 10^{23}$

$= 2.1 \times 10^{23}$ atoms

C. $n(\text{atoms}) = 14 \times n(C_4H_{10}) = 14.0 \times 0.5 = 7$ mol

$N(\text{atoms}) = n \times N_A = 7 \times 6.0 \times 10^{23}$

$= 4.2 \times 10^{24}$ atoms

D. 1 mole of C_4H_{10} has a mass of 58 g.

1 molecule of C_4H_{10} has a mass of $\left(\frac{58}{6.0 \times 10^{23}}\right)$ g.

Therefore **D** is incorrect and so is the required answer.

Question 11 **D**

Saucepan handles require strong materials with high melting points. The cross-linked structure in **D** is suitable.

Question 12 **A**

$\%\text{Ca} = \frac{m(\text{Ca})}{m(\text{TOTAL})} \times \frac{100}{1}$

Therefore, the substance with the highest percentage of calcium will be the one with lowest total molar mass (each compound has only one Ca in its formula). Therefore, $CaCO_3$ has the highest percentage of calcium.

Question 13 **B**

$n(Na_2CrO_4) = \frac{m}{M} = \frac{130}{162}$

$n(\text{O}) = 4 \times n(Na_2CrO_4) = \frac{4 \times 130}{162}$

$N(\text{O}) = n \times N_A = \frac{4 \times 130}{162} \times 6.0 \times 10^{23}$

$= 1.9 \times 10^{24}$ atoms

Question 14 **C**

The nucleus is not affected in chemical reactions, so no metal can be chemically changed into a different element (gold or otherwise).

Question 15 **B**

The relevant models and scientists are:
I – Bohr;
II – Quantum mechanics;
III – Thomson; and
IV – Rutherford.

Question 16 **C**

$^{A}_{Z}X$,

A = mass number = number of protons plus number of neutrons.
Z = atomic number = number of protons (equals number of electrons in a neutral atom).

The 3– charge indicates gain of three electrons.

Therefore, there are 15 protons, 15 + 3 = 18 electrons and 31 – 15 = 16 neutrons.

Question 17 **A**

Copper is a good conductor of heat, hence in A the wax will melt quickly and the bearing will be lost. Glass, graphite and wood are poor heat conductors, hence more time will be taken for the wax to become warm enough to melt.

Question 18 **B**

P (2, 8, 2), Q (2, 6), R (2, 8, 7), S (2, 8, 8, 1)

The correct formulas would be SR (so it is not **A**), PR_2 (so **B** is correct), PQ (so it is not **C**) and S_2Q (so it is not **D**).

Question 19 **D**

I – ionic solid II – polyethene III – diamond

Surface energies from highest to lowest are diamond (III), ionic solid (I), polyethene (II).

Question 20 **A**

Hydrophilic = water-'loving'. These water-attracting surfaces have high surface energy so that strong adhesive forces overcome the cohesive forces (hydrogen bonding) between water molecules. Therefore, water wets these surfaces.

Section B – Short-answer questions

Question 1

a. **i.** C
ii. B
iii. A
iv. B
v. C

b. D and E

Question 2

a. **i.** O or P
ii. N
iii. P

b. L conducts electricity, but is a liquid at room temperature and therefore unsuitable to use as wire.

M conducts electricity but melts at 29°C and could therefore become liquid if the wire heated during passage of electricity.

O conducts electricity and does not melt until 1083°C, hence it is most suitable for use as a wire.

P only conducts electricity when molten and therefore is not suitable to use as a wire.

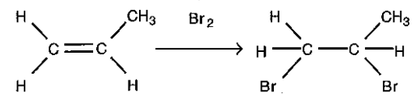
c. **i.** The alloy would become harder, but brittle.
ii. Rapid cooling produces many small crystals. These do not move past each other easily, producing a hard metal. Many small crystals allow cracks to move easily across the metal. Hence, the metal becomes brittle.

Question 3

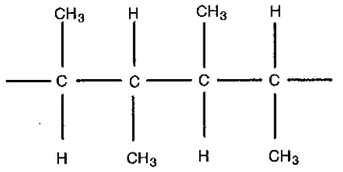
a. Y is a larger molecule, hence it would have stronger dispersion forces between molecules than X. Stronger forces give a higher boiling point.

b. **i.** C_nH_{2n}
ii. 2-methylpent-2-ene

c.



d. **i.**



ii. Dispersion forces

iii. Thermosoftening, because forces between the chains are weak dispersion forces only.

Question 4

a. **i.**

	C	H	O
mass ratio	40.91	4.55	54.54
RAM	12.0	1.0	16.0
ratio	3.409	4.55	3.409
simplify	1.00	1.335	1.00

Therefore, the empirical formula is $C_3H_4O_3$.

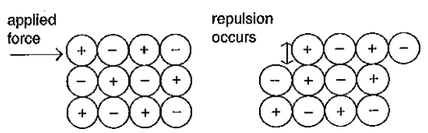
ii. The empirical formula mass is 88.
The molecular formula mass is 176 (= 88 × 2).
Hence, the molecular formula is $C_6H_8O_6$.

b. $n(\text{vitamin C}) = \frac{m}{M} = \frac{250 \times 10^{-3} \times 0.65}{176} = 9.2 \times 10^{-4}$ mol

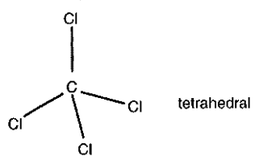
Question 5

a. **i.** Cs^+ and Cl^-

ii. Movement of ions when a force is applied results in ions of like charge being placed together. The repulsion of the like charges causes the crystal to shatter.



b. **i.**



ii. Although each C–Cl bond is polar, $\overset{\delta+}{C}\text{—}\overset{\delta-}{Cl}$, the molecule is non-polar because there is an overall even distribution of partial charges due to the symmetry of the molecule.

iii. Between CCl_4 molecules, there are only weak dispersion forces, hence the melting point is low.

Question 6

a. i. $1s^2 2s^2 2p^6$

ii. Atoms of aluminium have three occupied electron shells.

iii. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$

iv. It has a partially filled 3d subshell.

b. i. The magnesium nucleus has 12 protons, one less than the number of protons in an aluminium nucleus. Since both have the same number of electron shells, the electrons are more strongly attracted to the aluminium nucleus, thus producing a smaller radius.

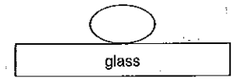
ii. $$\text{RAM} = \frac{\sum(\text{RIM} \times \%\ \text{abundance})}{100}$$
$$= \frac{(23.995 \times 78.99) + (24.996 \times 10.00) + (25.980 \times 11.01)}{100}$$
$$= 24.31$$

Question 7

a. i. The energy required to create a new unit of surface area.

ii. The metallic bonding in mercury is stronger than the ionic bonding in glass.

b. i.



ii. The cohesive forces (metallic bonds) are stronger than the adhesive forces between mercury and glass (ion–dipole). Hence, the mercury beads.

Practice Exam 3

Section A – Multiple-choice questions

Question 1 **B**

Members of a homologous series differ by CH_2.

Question 2 **A**

SiO_2, SiC and C (diamond) are covalent network lattices. Cu is metallic, NaCl is ionic, paraffin wax and polyethene are molecular, graphite is a covalent layer lattice and glass is largely ionic.

Question 3 **A**

Both molecules are C_4H_{10}. They are saturated (C_nH_{2n+2}) isomers whose physical properties differ. Statement **A** is incorrect, so it is the required response.

Question 4 **D**

The modern table orders elements by atomic number and vertically by outer-shell electron configuration.

Question 5 **D**

The relevant calculations are:

A: $n(\text{N}) = 2 \times n(\text{N}_2) = 2 \times \frac{m}{M} = \frac{2 \times 20.5}{28} = 1.46$ mol

B: $n(\text{N}) = 2 \times n(\text{N}_2\text{H}_4) = 2 \times \frac{m}{M} = \frac{2 \times 21.7}{32} = 1.36$ mol

C: $n(\text{N}) = n(\text{NO}_2) = \frac{N}{N_A} = \frac{6.02 \times 10^{22}}{6.02 \times 10^{23}} = 0.10$ mol

D: $n(\text{N}) = \frac{N}{N_A} = \frac{3.01 \times 10^{24}}{6.02 \times 10^{23}} = 5.0$ mol

Question 6 **D**

Monomers require a double C–C bond, found only in **B**.

Question 7 **C**

Elements in a group have the same outer-shell configuration (so IV is true). Their properties change down the group due to increasing size (so III is true). The number of occupied electron shells increases down a group (so II is not true). Ionisation energy decreases down a group (so I is not true).

Question 8 **C**

The structure shows a 6 : 6 coordination.
The ratio of ions is 1 : 1.

Question 9 **B**

In **A**, the carbon atom has 5 bonds, which is impossible.
In **C** and **D**, carbon atoms have only 3 bonds, which is also impossible.

Question 10 **B**

Counting the atoms present in the molecule gives $C_{14}H_{10}Cl_4$.
Simplifying the ratio for empirical formula gives $C_7H_5Cl_2$.

Question 11 **C**

$n(K_2Cr_2O_7) = \frac{m}{M} = \frac{882}{294.2} = 3.0$ mol

$n(\text{O}) = 7 \times n(K_2Cr_2O_7) = 7 \times 3.0 = 21$ mol

$N(\text{O}) = n \times N_A = 21 \times 6.02 \times 10^{23} = 1.26 \times 10^{25}$ atoms

Question 12 **A**

Alloys have a less regular lattice than metals, hence they are poorer conductors and less malleable/ductile. One of the primary reasons for alloying is to increase corrosion resistance. Lustre may or may not alter with alloying.

Question 13 **D**

Mass number = atomic number + number of neutrons.
Number of electrons = atomic number for a neutral atom.
$\therefore$ for X, $59 = 27 + k$ $\therefore$ $k = 32$
for Y, $39 = m + 20$ $\therefore$ $m = 19$
For X, +2 valency indicates loss of two electrons:
$27 - 2 = 25$ (*l*).
For Y, loss of one electron (19 – 18) gives valency of +1 (*n*).

Question 14 **A**

Atomic number 27.
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$

Question 15 **C**

Atomic number 19, Potassium, Group 1, Period 4.

Question 16 **B**

X – transition metal.
Y – Group 1 metal.
Malleability, good electrical conductivity and melting point above 25°C are all properties of metals (except Hg). Formation of coloured compounds is characteristic of transition metals.

Question 17 **A**

Intermolecular bonding is relatively weak. It is much weaker than the covalent bonds in N_2 and diamond, and the metallic bond in lead.

Question 18 **C**

An alkene has the general formula C_nH_{2n}. Hence if $n = 5$, $y = 10$.

Question 19 **D**

Higher surface tensions produce a greater 'pull' and hence greater capillary rise.
A narrower diameter tube means the same weight of liquid can be moved to a greater height.

Question 20 **B**

A and **D** give an indication of surface energy but are not the definition. Energy is required to create a surface, so **C** is incorrect.

Section B – Short-answer questions

Question 1

a. i. $C_4H_5ON_2$

ii. $$\%\text{N} = \frac{m(\text{N})}{m(C_8H_{10}O_2N_4)} \times \frac{100}{1}$$
$$= \frac{4 \times 14}{194} \times \frac{100}{1}$$
$$= 28.9\%$$

b. 6.02×10^{23} molecules = 194 g
1 molecule = x g
$x = 3.22 \times 10^{-22}$ g

c. i. $n = \frac{m}{M} = \frac{110 \times 10^{-3}}{194}$
$= 5.67 \times 10^{-4}$ mol

ii. $n(\text{C}) = 8 \times n(C_8H_{10}O_2N_4)$
$= \frac{8 \times 110 \times 10^{-3}}{194}$
$N(\text{C}) = n \times N_A$
$= \frac{8 \times 110 \times 10^{-3}}{194} \times 6.02 \times 10^{23}$
$= 2.73 \times 10^{21}$ atoms

Question 2

a. A thermosetting plastic softens and melts when heated.

b. IV chars when heated due to extensive covalent cross-linking.

c. Branching in II prevents close contact of chains. This reduces dispersion forces and hence lowers the melting point.

d. IV. Extensive covalent cross-linking produces a very hard and strong material.

Question 3

a. Sodium has an electronic configuration $1s^2 2s^2 2p^6 3s^1$. The removal of sodium's only electron in the third shell represents the first ionisation energy, which is relatively low, since this electron is further from the nucleus than the other electrons. Removal of the next four electrons is significantly harder since these electrons are found in the second shell, closer to the nucleus.

Magnesium has an electronic configuration $1s^2 2s^2 2p^6 3s^2$. The removal of magnesium's two third-shell electrons requires significantly less energy than the removal of the next three electrons, which are found in the second shell (closer to the nucleus).

b. Magnesium chloride ($MgCl_2$) is an ionic compound, with strong ionic bonds between magnesium ions and chloride ions. Thus, $MgCl_2$ exhibits a relatively high boiling point.

Cl_2 molecules are non-polar and are thus held together by weak intermolecular dispersion forces. These are relatively easy to break, so Cl_2 exhibits a lower boiling point than $MgCl_2$.

Question 4

a. $100 - 39.5 = 60.5\%$

b. RAM = $\sum$(RIM × abundance fraction)

Let x represent the relative isotopic mass of the second isotope.

$$\text{Thus, } 69.7 = \frac{(39.5 \times 70.8) + (60.5x)}{100}$$

$$\therefore 6\,970 = 2\,796.6 + 60.5x$$

$$\therefore 4\,173.4 = 60.5x$$

$$\therefore x = 69.0$$

The relative isotopic mass of the second isotope is 69.0.

c. $^{69}_{31}Ga^{3+}$

Question 5

a. **i.** Isotopes of an element contain different numbers of neutrons, and hence have different masses. They have the same number of protons, and hence belong to the same element.

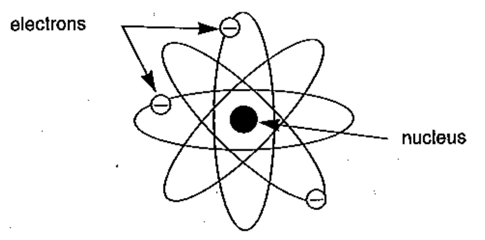
ii. For example:

1. Atoms are divisible into protons, neutrons and electrons.

3. Atoms of different elements have different masses. While masses may be similar due to neutron numbers, masses would not be exactly the same.

4. Atoms can change their identity during nuclear reactions, and are thus not indestructible (e.g. fission reactions).

b. **i.** A central nucleus containing the positive charge. Electrons circling the nucleus.



ii. For example:

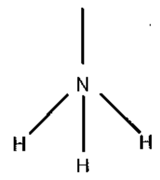
The nucleus contains neutrons as well as protons.

Electrons occupy shells.

Electrons have fixed energy.

Question 6

a. **i.**



ii. pyramidal

iii. polar

b. **i.** Boiling point is determined by the strength of forces between the molecules of PH_3. These are weak dispersion forces, hence the melting point is low. The P — H bond is not affected during the boiling process.

ii. Dispersion forces.

With increasing size of molecules (number of electrons), the strength of dispersion forces increases, hence the boiling point increases.

Question 7

a.

	Classification	Example	Use
1	covalent network	diamond	glass cutting tool
2	molecular	methane	fuel
3	ionic	sodium chloride	food preservative
4	metallic	copper	electrical wiring

b. **i.** 2

ii. 3

Question 8

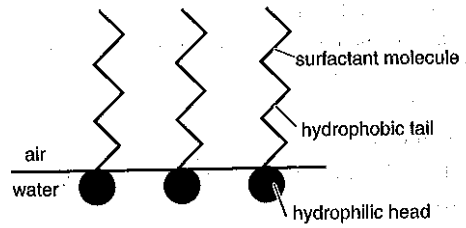
a. **i.** cohesive (beads)

ii. metallic bonds

iii. ionic or ion–dipole bonds

b. **i.** a surfactant (detergent)

ii.



The surfactant molecules lower the surface tension of the water. The cohesive forces between water molecules are decreased, hence the drop flattens. *The hydrophobic surfactant tails also interact with the waxy, non-polar leaf surface.*

iii. To allow better absorption of the pesticide.

Periodic Table

1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc 98.1	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

Lanthanides

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.3	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

Actinides

90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.1	94 Pu (244)	95 Am (243)	96 Cm (251	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)