INSIGHT

Year 11 ***Trial Exam Paper***

2012

CHEMISTRY

Written examination 1

Solutions book

This book presents:

- correct solutions with full working
- explanatory notes
- mark allocations
- tips and guidelines

SECTION A – Multiple-choice questions

Question 1

The elements of the periodic table were not discovered all at once. In fact, their discovery has spanned many centuries. Which of the elements listed below was isolated first?

A. **carbon**
B. helium
C. sodium
D. uranium

Answer is A

Worked solution

- A is correct. Carbon, in the form of soot and charcoal, has been known since ancient times. As soon as fire was common, charcoal was common.
- B is incorrect. Helium was isolated by Rayleigh and Ramsay in the late 19th century.
- C is incorrect. Sodium was isolated by Davy when electrolysis was invented in the early 19th century.
- D is incorrect. Uranium was discovered when radiation was discovered around the 1900s.

Tip

Sometimes common sense or general knowledge is expected. Carbon can be charcoal or soot. Fire has been known to man for a long time.

Question 2

S Ar Ca Al K

An ion with the electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^6$ is formed from one of the elements listed above. The element could only have been

A. Ar
B. Ar, Ca or K
C. **S, K or Ca**
D. S, K, Ar or Al

Answer is C

Worked solution

- C is correct. The electron configuration is that of argon. However, the question asks for an ion, so argon itself is not an answer but the elements either side of it in the above list (i.e. S, K and Ca) are.
- A is incorrect as argon does not form ions.
- B is incorrect as it includes argon.
- D is incorrect as it includes argon and aluminium. Aluminium will lose electrons when it forms an ion to give a configuration of $1s^2 2s^2 2p^6$.

Question 3

What is the chemical formula of the likely compound formed from the elements with the following electronic configurations?

X $1s^2 2s^2 2p^6 3s^2 3p^1$ Y $1s^2 2s^2 2p^4$

A. XY

B. XY_3

C. X_2Y

D. $\mathbf{X_2Y_3}$

Answer is D

Worked solution

- D is correct. Element X has 3 electrons in the outer shell so will form X^{3+}, while Y has 6 electrons in its outer shell so will form Y^{2-}. The correct formula between these two ions will be X_2Y_3.
- A is incorrect as the two ions do not have the same charge.
- B is incorrect as the charge on X is not three times that of Y.
- C is incorrect as the charge on Y is not double that of X.

Question 4

Which of the following represents the greatest number of hydrogen atoms?

A. **10 g of H atoms**

B. 9 g of H_2 molecules

C. 15 g of water, H_2O

D. 15 g of methane, CH_4

Answer is A

Worked solution

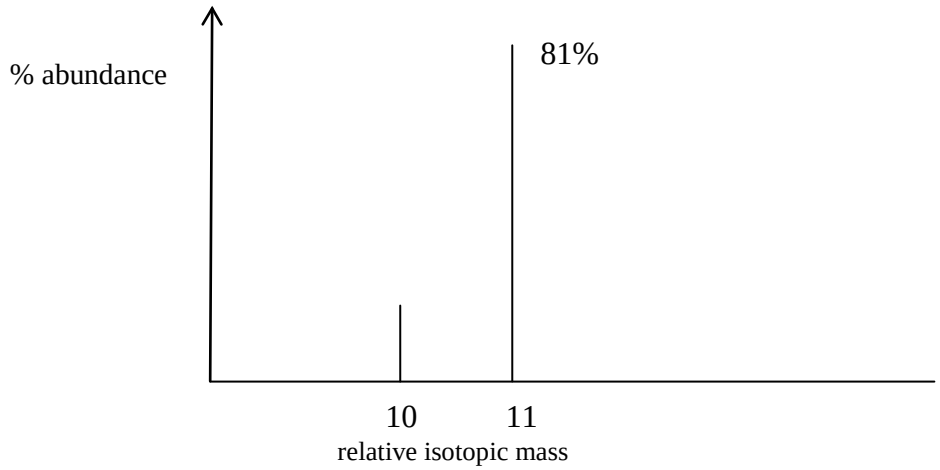
- A is correct. This can be deduced by working out the number of mole in each option. Some of the alternatives can be discounted quickly, however, because 10 g is obviously greater than 9 g in B and the compounds in the other options only have a small percentage of H. **Option A is** $= \frac{10}{1} = 10$ **mol**
- B is incorrect as it is $= \frac{9}{2} = 4.5$ mol. Therefore, $n(\text{H}) = 4.5 \text{ mol} \times 2 = 9 \text{ mol}$, which is less than A.
- C is incorrect as $n(\text{H}_2\text{O}) = \frac{15}{18} = 0.83$ mol. Therefore, $n(\text{H}) = 0.83 \times 2 = 1.66$ mol, which is less than A.
- D is incorrect as. $n(\text{CH}_4) = \frac{15}{16} = 0.94$ mol. Therefore, $n(\text{H}) = 0.94 \times 4 = 3.75$ mol, which is less than A.

Tip

It is possible to calculate a number of mole for each alternative. However, this is time consuming. Look for ways to discount answers. For example, option C has a small percentage by mass of hydrogen. It does not require a calculation to see that it will have a lower mass of hydrogen than either option A or B.

Questions 5 and 6 refer to the following information.

The mass spectrum for boron is shown.



Question 5

From the mass spectrum for boron it can be concluded that boron

A. has two isomers

B. has two isotopes, the second with one more proton than the first

C. **has two isotopes, the second with one more neutron than the first**

D. can form ions with two different oxidation numbers

Answer is C

Worked solution

- C is correct. The mass spectrum shows two peaks, therefore two isotopes. The difference in mass is 1, so the second peak has one more neutron than the first peak.
- A is incorrect as *isomers* is not the correct term for *isotopes.*
- B is incorrect as it is neutrons that differ in number, not protons.
- D is incorrect as the ions both have the same charge. It is their mass that is different.

Question 6

The relative atomic mass of boron will be

A. 10.00
B. 10.19
C. 10.50
D. **10.81**

Answer is D

Worked solution

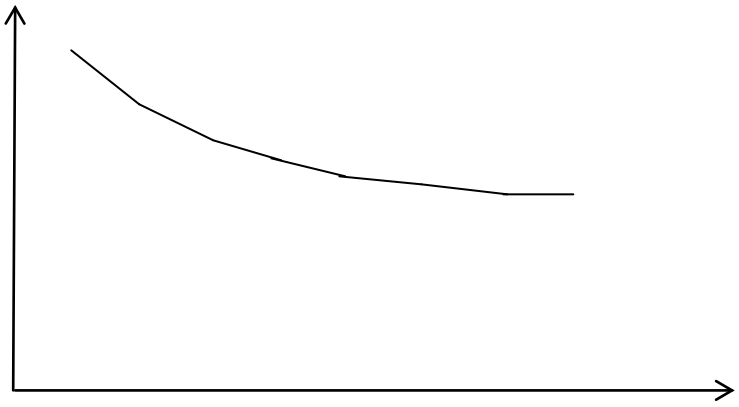
- D is correct: $\text{RAM}=\frac{10\times19+11\times81}{100}=10.81$
- A is incorrect as the RAM will surely be greater than 10.
- B is incorrect as the RAM will be closer to 11 than to 10, as the peak at 11 is bigger.
- C is incorrect as the RAM will be closer to 11 than to 10 as the peak at 11 is bigger.

Tip

Use your Data Book. The answer of 10.8 is on the periodic table. This enables you to bypass a calculation.

Question 7

The graph below shows how a particular property changes as you move across period 3 of the periodic table.



From the shape of this curve, the property being measured might be

A. **atomic radius**
B. melting point
C. electronegativity
D. density

Answer is A

Worked solution

- A is correct. The atomic radius decreases as you move across a period. The pull of the nucleus on the outer-shell electrons increases as the number of protons in the nucleus increases. This pulls the outer shell closer to the nucleus, making the atoms smaller.
- B is incorrect. Melting points fluctuate over a period with the final elements in the period gases.
- C is incorrect. Electronegativity increases across the period.
- D is incorrect. Density fluctuates from low to high to low across the period

Question 8

Nitrogen forms many different compounds when it reacts with oxygen. A 5.00 g sample of one particular oxide of nitrogen is found to contain 1.52 g of nitrogen. The empirical formula of the oxide is

A. NO

B. **NO_2**

C. N_2O

D. NO_3

Answer is B

Worked solution

- B is correct. A calculation of empirical formula is needed to verify this.
  mass of nitrogen = 1.52g
  mass of oxygen is the remainder of the 5g=5-1.52=3.48g
  $\frac{1.52}{14} : \frac{3.48}{16} = 0.109 : 0.218 = 1 : 2 = NO_2$
- A is incorrect. Empirical formula is calculated as NO_2.
- C is incorrect. Empirical formula is calculated as NO_2.
- D is incorrect. Empirical formula is calculated as NO_2.

Question 9

The properties of a particular substance are

Melting point	896°C
Electrical conductivity (solid)	low
Electrical conductivity (liquid)	high
Solubility in water	high
Brittle	

The compound is most likely to be

A. **NaCl**

B. CO

C. Mg

D. diamond

Answer is A

Worked solution

- A is correct as all the properties point to an ionic solid and NaCl is the only ionic solid on the list. Ionic solids conduct electricity as liquids but not as solids. NaCl is fairly soluble in water. It is brittle and has a relatively high melting point.
- B is incorrect as carbon monoxide will be a gas at room temperature and never conduct.
- C is incorrect as metals conduct as solids.
- D is incorrect as diamond is not soluble or conductive.

Question 10

Which list contains only organic compounds that are saturated?

A. propane, CH_4, $CH_3CHCHCH_2CH_3$

B. **butane, C_3H_8, $CH_3CH_2CH_2CH_3$**

C. butane, C_3H_6, CH_2CHCH_3

D. pentane, $CH_3CH_2CH_2CH_2CH_3$, C_4H_8

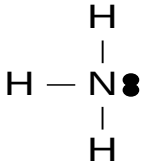
Answer is B

Worked solution

- B is correct as each of the three substances are alkanes. Butane is an alkane, C_3H_8 matches C_nH_{2n+2} for alkanes and the structural formula given has all CH_3CH_2 etc. so it cannot have a double bond.
- A is incorrect as the third alternative, $CH_3\underline{CHCH}CH_2CH_3$, will have a double bond in the underlined section.
- C is incorrect as C_3H_6 is an alkene and CH_2CHCH_3 will have a double bond.
- D is incorrect as C_4H_8 is an alkene.

Question 11

The molecule shown is ammonia.



The nitrogen atom in an ammonia molecule has

A. six electrons in the outer shell

B. one lone pair of electrons and three shared electrons

C. **one lone pair of electrons and three pairs of bonding electrons**

D. eight bonding electrons in the outer shell

Answer is C

Worked solution

- C is correct as the three covalent bonds represent three pairs of electrons and there is a non-bonding pair on the right of the molecule.
- A is incorrect as the nitrogen atom in ammonia has eight electrons in the outer shell.
- B is incorrect as there are six shared electrons.
- D is incorrect as two of the electrons in the outer shell are non-bonding.

Question 12

The molecule carbon tetrafluoride has the formula CF_4. Carbon tetrafluoride will contain

A. no dipoles and be non-polar
B. **dipoles but be non-polar**
C. dipoles and be polar
D. ionic bonds

Answer is B

Worked solution

- B is correct as each C–F bond will have a significant dipole. However, the four dipoles will cancel each other out, making the molecule non-polar as a whole.
- A is incorrect as the molecule will have dipoles.
- C is incorrect as the molecule is not polar.
- D is incorrect as there will be no ions present in a molecular compound.

Tip

If in doubt on questions like this, take the time to draw an electron dot diagram. The shape and bonding is easier to deduce from an electron dot diagram.

Question 13

Most of the alkane molecules are fuels. When they burn in excess air, the reaction is called a combustion reaction. The products of combustion reactions will be

A. carbon and hydrogen
B. **carbon dioxide and water**
C. carbon and water
D. carbon dioxide and hydrogen

Answer is B

Worked solution

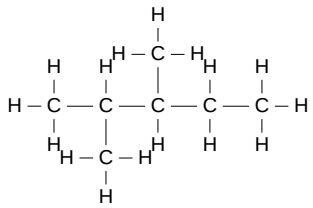
- B is correct as the products of a complete combustion of organic compounds are always carbon dioxide and water. Using methane as an example:
  $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
- A is incorrect as hydrogen is too reactive to be a product and the carbon will form carbon dioxide as in part C
- C is incorrect as the carbon will form carbon dioxide.
- D is incorrect as hydrogen is too reactive to be a product.

Tip

Combustion equations can be asked on both Unit 3 and Unit 4 exams. It is in your interests to master these as soon as possible.

Question 14

The correct IUPAC name for this compound is



A. **2,3-dimethylpentane**
B. 2,3-methylpentane
C. 2,3-dimethylheptane
D. heptane

Answer is A

Worked solution

- A is correct as the longest chain of carbons contains five carbon atoms, making it a pentane. There is a methyl group on the second and third carbon atoms, making it 2,3-dimethylpentane.
- B is incorrect as it should be 'dimethyl'.
- C is incorrect as the longest chain of carbons matches pentane.
- D is incorrect as the longest chain of carbons matches pentane. The molecule is actually an isomer of heptane.

Question 15

An alkene has a molar mass of 70 g mol^{-1}. The alkene is

A. ethene
B. butane
C. pentane
D. **pentene**

Answer is D

Worked solution

- D is correct as pentene is the only alkene with a molar mass of 70.
  $C_5H_{10} = 12 \times 5 + 1 \times 10 = 70$ g mol^{-1}
- A is incorrect as ethene has a molar mass of 28 g mol^{-1}.
- B is incorrect as butane is not an alkene.
- C is incorrect as pentane has a molar mass of 72 g mol^{-1} and pentane is not an alkene.

Question 16

NaCl H_2O Pb N_2 diamond CH_4

The likely order of melting points, from lowest to highest, for the list of substances above will be

A. N_2, CH_4, H_2O, Pb, diamond, NaCl

B. N_2, Pb, CH_4, H_2O, NaCl, diamond

C. N_2, NaCl, H_2O, CH_4, Pb, diamond

D. **N_2, CH_4, H_2O, Pb, NaCl, diamond**

Answer is D

Worked solution

- D is correct. N_2 is a gas at –196°C. CH_4 is natural gas, which is still a gas but turns to a liquid and a solid more easily than nitrogen. Water is a liquid at room temperature and so comes next. Lead is easy to melt to form shotgun pellets so it has a lower melting point than NaCl. Diamond is still a solid at well over 3000°C, making it the most heat-resistant substance on the list.
- A is incorrect as diamond has a higher melting point than NaCl.
- B is incorrect as Pb is a metal with a higher melting point than methane gas, CH_4.
- C is incorrect as water is a liquid at room temperature and has a higher melting point than natural gas. NaCl will have a higher melting point than H_2O and CH_4.

Question 17

Diamond is an allotrope of carbon. It does not melt to a liquid, rather it sublimes at very high temperatures. The reason for the high sublimation temperature is that

A. the molecules in diamond are very long

B. **it is a giant covalent lattice with no discrete molecules**

C. it has a sea of electrons as metals do

D. the molecules in diamond have some cross-links

Answer is B

Worked solution

- B is correct as diamond forms an infinite covalent lattice. It has strong covalent bonds joining all of the carbon atoms present. It does not have discrete molecules.
- A is incorrect as diamond does not have discrete molecules.
- C is incorrect as the sea of electrons is relevant to metals.
- D is incorrect as diamond does not have molecules.

Question 18

The structure of a polymer can be modified in many ways. Some of these possibilities are listed.

I Increase the length of the molecules.
II Replace a hydrogen atom in the monomer with a chlorine atom.
III Add branches to the chains.
IV Add cross-links to the polymer.

Which of the above changes will lead to an increase in the melting point of the polymer?

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

Answer is C

Worked solution

- C is correct. All options except III will increase the melting point. Longer molecules mean more dispersion forces between molecules. Adding chlorine to the structure adds significant dipoles, hence more bonding. Cross-linking will make covalent bonds between the molecules. Option III will make the molecules further apart, decreasing the impact of the dispersion forces between the molecules.
- A is incorrect as there are more correct options than IV.
- B is incorrect as option IV has been omitted.
- D is incorrect as option III should not be included.

Question 19

A thermoplastic polymer has

A. **very long molecules held together with dispersion forces and/or dipoles**
B. very long molecules held together by covalent cross-links
C. a network of molecules set into a giant array
D. a giant network of covalent bonds

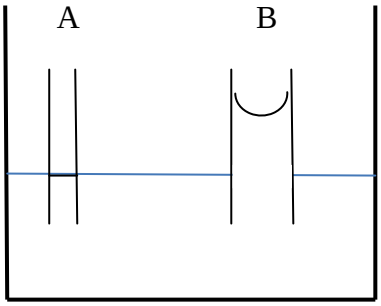
Answer is A

Worked solution

- A is correct as polymers have long molecules. The long molecules are held together by dispersion forces and sometimes dipoles as well. (Polyethene does not have dipoles but PVC does.)
- B is incorrect as thermoplastic polymers will not have cross-links.
- C is incorrect as polymers are not giant arrays.
- D is incorrect as polymers are not giant networks.

Question 20

The diagram shows two capillary tubes sitting in the same beaker of water.



From the diagram, and from your knowledge of capillary action, it can be concluded that

A. water does not rise as far in narrow glass tubing
B. **tubing A might be made from plastic and tubing B from glass**
C. tubing B has been left in the liquid a lot longer than tubing A
D. tubing A might be made from glass and tubing B from plastic

Answer is B

Worked solution

- B is correct as capillary action causes water to rise up a glass column. Tubing B is a glass column. Tubing A has no such rise so is probably a material that has much less attraction to water. Polymers, or plastics, are such materials.
- A is incorrect as capillary action should lead to a greater rise in the narrow tubing if they are both made from the same material.
- C is incorrect as the length of time is fairly irrelevant, as long as the water has had a small time to rise to wherever it is going.
- D is incorrect as it has the two materials the wrong way around.

END OF SECTION A

END OF SECTION A
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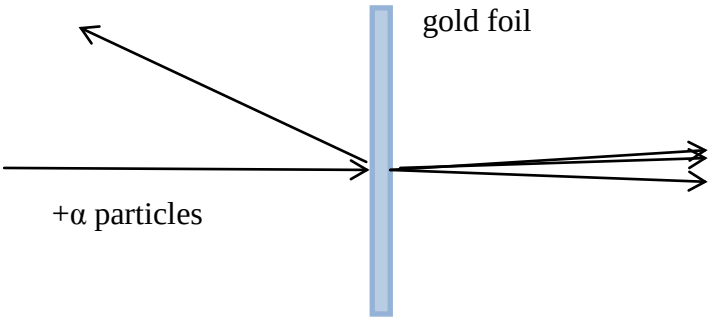
SECTION B – Short-answer questions

Question 1

The discovery of radiation provided a new tool for scientists to use in their investigation of the atom. One scientist to make an important contribution was New Zealander Ernest Rutherford. Rutherford's team directed a beam of positively charged alpha particles at a very thin sheet of gold foil. The research team noticed that:

- most of the alpha particles passed through the foil with only a slight deviation in their path
- a small number of particles were deflected significantly, some even rebounding back towards the source of the particles.

These observations led to some surprising conclusions.



1a. What conclusion did Rutherford draw from the fact that most alpha particles passed through the gold foil?

1 mark

Solution

Most of the atom is space.

Marking allocation

- 1 mark for explanation that the atom is mostly space.

Explanatory notes

If most of the alpha particles passed through, then they did not collide with anything. The atom, therefore, cannot be a solid sphere or a 'plum pudding' as Thomson had proposed earlier.

Tip

The 'history of atomic theory' is on the course. There are not many aspects of this history that are easy to ask about. Rutherford, Dalton and Bohr are highly probable examples as their discoveries are easy to understand. Therefore, for each topic you revise, ask yourself 'Are there highly probable things to practise?'

1b. Give two conclusions Rutherford made from the observation that a small percentage of alpha particles rebounded from the gold foil.

2 marks

Solution

The atom has a small nucleus. The nucleus has a strong positive charge.

Marking allocation

- 1 mark for each conclusion.

Explanatory notes

The alpha particles rebound because they collide with a positive charge in the atom. Like charges will repel each other. Since only a small percentage of particles rebound, these spots of positive charge must be small. Rutherford called the areas of positive charge the 'nucleus' of the atom.

1c. Danish scientist Niels Bohr communicated frequently with Rutherford. In 1913, he proposed a modification to the picture of the atom developed by Rutherford. Explain what Bohr proposed.

1 mark

Solution

Bohr is well known for explaining that the electrons do not wander at random in an atom. They are located in particular shells.

Marking allocation

- 1 mark for mentioning that Bohr explained that electrons occupy 'shells'.

Explanatory notes

Bohr proposed that the electrons in an atom circled the nucleus without losing energy. They could only move in certain fixed orbits. He was responsible for explaining that atoms had electron shells.

1d. In 1932, English scientist James Chadwick identified a further particle in the atom.

i. What was the name of this particle?

ii. Give one reason why the discovery of this particle did not come until several years after Rutherford's experiment.

1 + 1 = 2 marks

Solution

i. Chadwick is credited with the discovery of the neutron.

ii. The lack of charge on a neutron made it more difficult to identify.

Marking allocation

- 1 mark for neutron.
- 1 mark for mention of the lack of charge of a neutron.

Explanatory notes

Mass measurements of atoms suggested the presence of isotopes, different forms of the same element. It was Chadwick's experimenting that confirmed the existence of a neutral particle. Chadwick called this a neutron. It was harder to identify because of its lack of charge. The electron and proton were both identified from experiments that used their charge.

Total 6 marks

Question 2

Aluminium and chlorine both belong to period 3 on the periodic table.

2a. Describe how each of the following properties will change as you move across the elements of period 3.

i. electronegativity

ii. metallic character

iii. atomic radius

1 + 1 + 1 = 3 marks

Solution

i. Electronegativity increases as you move across a period.

ii. Metallic character decreases as you move across a period.

iii. Atomic radius decreases as you move across a period.

Marking allocation

- 1 mark for each trend correct.

Explanatory notes

The outer-shell electrons dictate the properties of an atom. As you move across a period, the number of outer-shell electrons increases. Atoms with few electrons in the outer shell are metals. They are likely to lose those electrons when they react. On the right-hand side of the period, the atoms have nearly complete outer shells. They are likely to gain electrons, so their electronegativity is higher and their metallic character is less. The decreasing atomic radius can seem strange, but it is explained in terms of 'core charge'. The extra protons in the nucleus pull the outer-shell electrons closer to the nucleus, making the atoms on the right smaller.

Tip

We study the periodic table because it enables us to predict properties. Learn these trends off by heart as they are useful.

Aluminium and chlorine can react to form a compound. (Use full subshell notation for all electron configurations asked for in this question.)

2b. **i**. Write the electronic configuration of aluminium.

ii. Write the electronic configuration of the likely ion that aluminium will form.

1 + 1 = 2 marks

Solution

i. $1s^2 2s^2 2p^6 3s^2 3p^1$

ii. $1s^2 2s^2 2p^6$

Marking allocation

- 1 mark for each electron configuration that is exactly correct.

Explanatory notes

Aluminium is element number 13, so it has 13 electrons. The order that the shells fill leads to three electrons in the outer shell. When an ion forms, the three outer-shell electrons are lost.

Tip

Learn the order that electrons populate orbitals. If you cannot remember the usual diagram with arrows, determine the order from the periodic table. Notice that aluminium is in group 13, suggesting three electrons in the outer shell.

2c. **i**. Write the electronic configuration of chlorine.

ii. Write the electronic configuration of the likely ion that chlorine will form.

1 + 1 = 2 marks

Solution

i. $1s^2 2s^2 2p^6 3s^2 3p^5$

ii. $1s^2 2s^2 2p^6 3s^2 3p^6$

Marking allocation

- 1 mark for each electron configuration that is exactly correct.

Explanatory notes

Chlorine is element number 17, so it has 17 electrons. The order that the shells fill leads to seven electrons in the outer shell. When an ion forms, it gains one electron to complete the outer shell.

2d. **i**. What is the name, and chemical formula, of the compound formed between aluminium and chlorine?

Name: _____ Chemical formula: _____

ii. List three properties of this compound.

2 + 3 = 5 marks

Solution

i. Name: aluminium chloride. Chemical formula: $AlCl_3$

ii. Choose from high melting point, brittle, non-conductor as solid, conductor as liquid.

Marking allocation

- Part i: 1 mark for name, 1 mark for formula.
- Part ii: 1 mark for each correct property.

Explanatory notes

The two ions are Al^{3+} and Cl^-.
When the two ions combine, three chloride ions are needed to match the aluminium.
Formula is $AlCl_3$.

Tip

- *Again, the writing of correct formulas is virtually a mandatory skill in chemistry. It is relevant to all topics. Practise this until you have the skill learnt.*

Total 12 marks

Question 3

Complete the following table.

Name of compound	Formula of compound
potassium oxide	
iron(III) fluoride	
calcium nitride	
	$Mg(OH)_2$
	$Al_2(SO_4)_3$

5 marks

Solution

Name of compound	Formula of compound
potassium oxide	K_2O
iron(III) fluoride	FeF_3
calcium nitride	Ca_3N_2
magnesium hydroxide	$Mg(OH)_2$
aluminium sulfate	$Al_2(SO_4)_3$

Marking allocation

- 1 mark for each correct response.

Explanatory notes

The main challenge to this question is knowing the charge on each ion present. The periodic table should show you that potassium is +1, calcium +2, fluorine –1 and nitrogen –3. The charge on iron is given by (III).

Tip

- *If you are unsure of a charge on an ion, look elsewhere on the exam to see if another question uses the ion. Sometimes useful information can be determined from the Data Book or from other questions.*

Question 4

Glucose is one of the most important carbohydrate molecules. Its molecular formula is $C_6H_{12}O_6$.

4a. **i**. What is the relative molecular mass of glucose?

ii. What is the molar mass of glucose?

1 + 1 = 2 marks

Solution

i. RAM = $(6 \times 12 + 12 \times 1 + 6 \times 16) = 180$

ii. Molar mass = 180 g mol^{-1}

Marking allocation

- 1 mark for each answer. Units are essential for part ii to be marked correct.

Explanatory notes

The value of 180 is obtained from the molecular formula of $C_6H_{12}O_6$. The difference between the two questions is that the first is 'relative molecular mass' and the second is 'molar mass'. The value of 180 is common to both answers but the molar mass needs units of grams per mol because it is compared to 12 g of carbon.

4b. Calculate the percentage mass of oxygen in glucose.

2 marks

Solution

$$\%O = \frac{\text{mass of oxygen}}{\text{mass of molecule}} \times \frac{100}{1} = \frac{16 \times 6}{180} \times \frac{100}{1} = 53.3\%$$

Marking allocation

- 1 mark for correct formula, 1 mark for correct answer.

Explanatory notes

The percentage mass is calculated by placing the mass of the element in question over the mass of the whole molecule and converting this to a percentage.

4c. In a 600 g sample of glucose, calculate the

i. amount, in moles, of glucose

ii. amount, in moles, of carbon atoms

iii. number of carbon atoms

1 + 1 + 1 = 3 marks

Solution

i. $n(\text{glucose}) = \frac{n}{M} = \frac{600}{180} = 3.33 \text{ mole}$

ii. $n(\text{C}) = 6 \times 3.33 = 20 \text{ mole}$

iii. Number carbon atoms = $20 \times 6.02 \times 10^{23} = 1.20 \times 10^{25}$

Marking allocation

- 1 mark for each correct answer. (Allow some variation in the answers as students might round the 0.3 recurring decimal differently.)

Explanatory notes

Part i is straight use of $n = \frac{m}{M}$.
Part ii refers to carbon, not glucose. Each glucose molecule has six carbon atoms, so multiply the answer to part i by 6.
Part iii does not refer to mole, hence the factor 6.02×10^{23} is needed. Multiply the answer to part ii by 6.02×10^{23}.

Tips

Always read the question carefully. It would be easy to miss the difference in the two parts: part i refers to the amount, in moles, of glucose; part ii refers to the amount, in moles, of carbon atoms.

Similarly, part iii does not refer to mole.

4d. A sample of a white powder is thought to be pure glucose. The mass of carbon in the sample is determined to be 4.8 g.

i. Calculate the mass of hydrogen that must be present for the sample to be glucose.

ii. Calculate the mass of oxygen that must be present for the sample to be glucose.

3 + 2 = 5 marks

Solution

i. $n(\text{C}) = \frac{m}{M} = \frac{4.8}{12} = 0.40 \text{ mol}$

$n(\text{H}) = 2 \times n(\text{C}) = 2 \times 0.40 = 0.80 \text{ mol}$

$\text{mass(hydrogen)} = n \times M = 0.8 \times 1 = 0.8\text{g}$

ii. $n(\text{O}) = n(\text{C}) = 0.40 \text{ mol}$

$\text{mass(O)} = n \times M = 0.4 \times 16 = 6.4\text{g}$

Marking allocation

- **Part i:** 1 mark for *n*(C). 1 mark for *n*(H). 1 mark for mass.
- **Part ii:** 1 mark for *n*(O). 1 mark for mass

Explanatory notes

This calculation could be done in many different ways, percentage mass being an option. As the molecular formula is $C_6H_{12}O_6$, the number of mole of hydrogen must be twice that of carbon and the number of mole of oxygen will be the same as for carbon. Therefore, the first step must be determining the number of mole of carbon.

Total 12 marks

Question 5

5a. Draw structural diagrams of the following molecules.

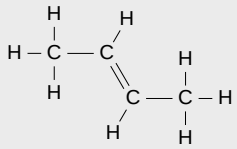
i. 2-butene

ii. 2-methylbutane

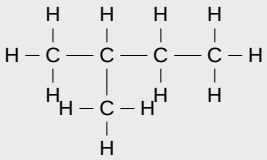
1 + 1 = 2 marks

Solution

i. 2-butene



ii. 2-methylbutane



Marking allocation

- 1 mark for each structure.

Explanatory notes

i. but = 4 and -ene = double bond. Therefore, the molecule has four carbon atoms and a double bond. The '2-' means the double bond is between the second and the third carbon atoms.

ii. 2-methyl means there is a methyl group on the second of the four carbon atoms and -ane means all carbon to carbon bonds are single bonds.

5b. Label each of the following as alkane or alkene.

i. C_8H_{18}

ii. $CH_3CHCHCH_2CH_3$

1 + 1 = 2 marks

Solution

i. C_8H_{18} alkane

ii. $CH_3CHCHCH_2CH_3$ alkene

Marking allocation

- 1 mark for each answer.

Explanatory notes

The general formula for alkanes is C_nH_{2n+2}, and for alkenes it is C_nH_{2n}.
Part i matches an alkane and part ii matches an alkene.

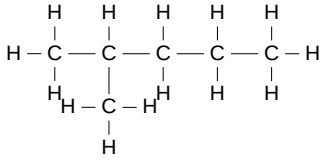
Tip

When semistructural formulas are given, an alkane has a row of –CH_2– in it.
Example pentane: $CH_3CH_2CH_2CH_2CH_3$

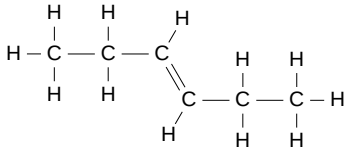
When the formula contains –CHCH–, then it is an alkene.
Example pentene: $CH_3CHCHCH_2CH_3$

5c. Name each of these molecules using correct IUPAC notation.

i.



ii.



1 + 1 = 2 marks

Solution

i. 2-methylpentane

ii. hex-3-ene or 3-hexene

Marking allocation

- 1 mark for each answer.

Explanatory notes

i. There are five carbon atoms in the chain, so it is pentane. The second carbon has a methyl group on it.

ii. There are six carbon atoms, so it is hexene. The double bond is between the third and fourth carbon.

Tip

The IUPAC system gives clear rules for naming organic compounds. Learn these rules off by heart.

5d. **i**. What is the molecular formula of 2-butene? _____

ii. What is the empirical formula of 2-butene? _____

1 + 1 = 2 marks

Solution

i. C_4H_8

ii. CH_2

Marking allocation

- 1 mark for each answer.

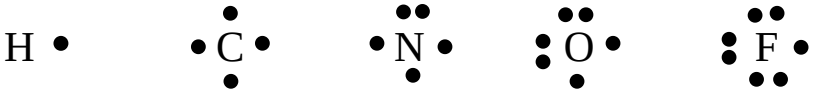
Explanatory notes

The general formula for an alkene is C_nH_{2n}. It makes no difference where the double bond is positioned.
The empirical formula is the simplest ratio of 4:8, which is 1:2.

Total 8 marks

Question 6

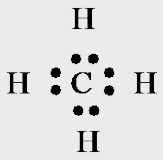
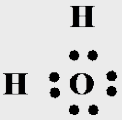
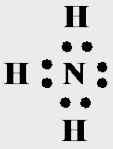
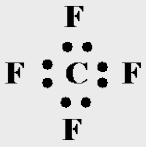
Electron dot diagrams of some common non-metals are provided below. Electron dot diagrams are helpful when determining the formulas and structures of compounds formed between these elements.



Use these electron dot diagrams to complete the table below. For each pair of elements, draw a valence diagram (electron dot diagram) of the most likely compound to form when they bond. Use the valence diagram to predict the shape of the molecule.

6 marks

Solution

	Valence diagram	Molecular formula	Shape
carbon and hydrogen		CH_4	tetrahedral
hydrogen and oxygen		H_2O	V-shaped
nitrogen and hydrogen		NH_3	trigonal pyramid
carbon and fluorine	 (Electrons around F atoms not shown.)	CF_4	tetrahedral

Marking allocation

- $\frac{1}{2}$ mark for each correct answer.

Explanatory notes

The key to the question is to draw an electron dot diagram for each compound. The aim in each molecule is to share enough electrons to make a complete outer shell for both elements. All of the compounds in the question have four pairs of electrons in the outer shell of the central atom.

Carbone and hydrogen: carbon requires four electrons so it bonds with four hydrogen atoms; hence, the formula is CH_4. With four equal bonds, the shape will be tetrahedral

Hydrogen and oxygen: oxygen requires two more electrons; hence, it bonds with two hydrogen atoms. The formula will be H_2O. The shape of this molecule will be V-shaped as there are four electron pairs to get as far away from each other as possible.

Nitrogen and hydrogen: nitrogen has five outer-shell electrons, so will bond with three hydrogen atoms to get eight electrons in the outer shell. The formula will be NH_3 and the shape is trigonal pyramid.

Carbon and fluorine: carbon has four outer-shell electrons so it bonds with four fluorine atoms. The compound is CF_4. The shape of this molecule will be tetrahedral.

Tips

The shapes of the HCl, H_2O, NH_3, CH_4 and CO_2 molecules are asked so frequently that they are worth remembering off by heart.

Question 7

CH_4 SiO_2 polyethene $MgCl_2$ Li C_6H_{14}

7a. Use the list of compounds above to complete the table below. A substance may be used more than once or not at all.

5 marks

Solution

A substance that conducts electricity as a liquid but not a solid	$MgCl_2$
A substance with covalent bonds and a very high melting point	SiO_2
A molecular substance with a relatively high melting point	polyethene
A substance that conducts electricity as a solid and as a liquid	Li
A substance that is a gas at room temperature	CH_4

Marking allocation

- 1 mark for each answer.

Explanatory notes

A substance that conducts electricity as a liquid but not as a solid must be an ionic solid. The only ionic substance on the list is $MgCl_2$.

A substance with covalent bonds and a very high melting point is silicon dioxide. Polyethene's melting point is not high enough to suit this answer.

A molecular substance with a relatively high melting point is polyethene. Polymers have very long molecules. Silicon dioxide is not correct as it is not molecular.

A substance that conducts electricity as a solid and as a liquid will be a metal, making lithium the obvious answer.

A substance that is a gas at room temperature: This would be methane, CH_4. The other alkane would be a liquid at room temperature.

7b. The bonding between two nitrogen atoms in an N_2 molecule is considered very strong. The boiling point of nitrogen gas, however, is very low –196°C. Explain this apparent contradiction.

2 marks

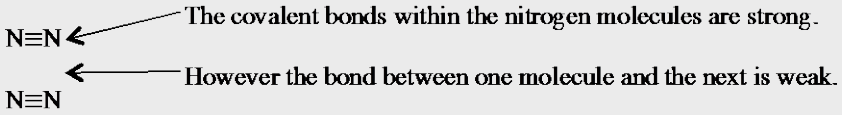
Solution

The bonding between two nitrogen atoms in an N_2 molecule might indeed be strong but the bonding between neighbouring nitrogen molecules is weak. Nitrogen has no dipoles so it is only dispersion forces that lead to any attraction between molecules.

Marking allocation

- 1 mark for distinguishing forces within molecules from forces between molecules.
- 1 mark for reference to absence of dipoles or ions.

Explanatory notes



It is the bonding between molecules that determines the melting point. There are no dipoles to lead to strong attraction, just dispersion forces.

Tip

A sketch can be an easy way to make your answer clearer. Don't hesitate to use sketches in an exam.

7c. A drop of water sits on a plastic plate in a ball shape. A similar drop of water on a glass plate spreads out to cover the glass. Explain the difference in the behaviour of water on the two surfaces.

2 marks

Solution

Glass and plastic are different surfaces. Glass is hydrophilic and will attract the water but plastic is hydrophobic so the water does not spread out on it.

Marking allocation

- 1 mark for identifying plastic as hydrophobic
- 1 mark for identifying water as hydrophilic. It is acceptable to explain this question without the use of these two terms.

Explanatory notes

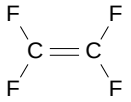
Water is a polar molecule. It will be attracted to surfaces that have charges in them, be it dipoles or ions. Glass contains both ions and dipoles, so water is attracted to it. Surfaces that attract water are hydrophilic. Polymers are relatively non-polar so they do not attract water. Polyethene is a hydrophobic surface.

Total 9 marks

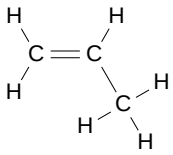
Question 8

8a. Draw the likely polymer formed from each monomer.

i.



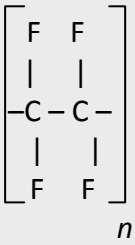
ii.



1 + 1 = 2 marks

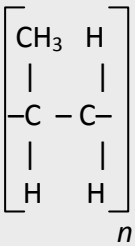
Solution

i.



n

ii.



n

Marking allocation

- 1 mark for each answer.

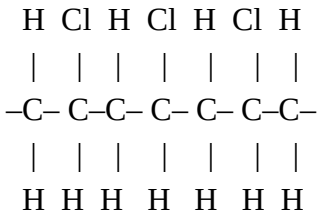
Explanatory notes

When the polymer forms, the double bond is lost.

Tip

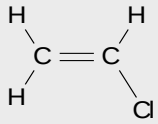
- *Notice that most of the polymers are variations of ethene. The polymer can be easy to draw if you remember the structure of ethene:* 

8b. A segment of a polymer is shown in the diagram. Draw the monomer that was used to form this polymer.



1 mark

Solution



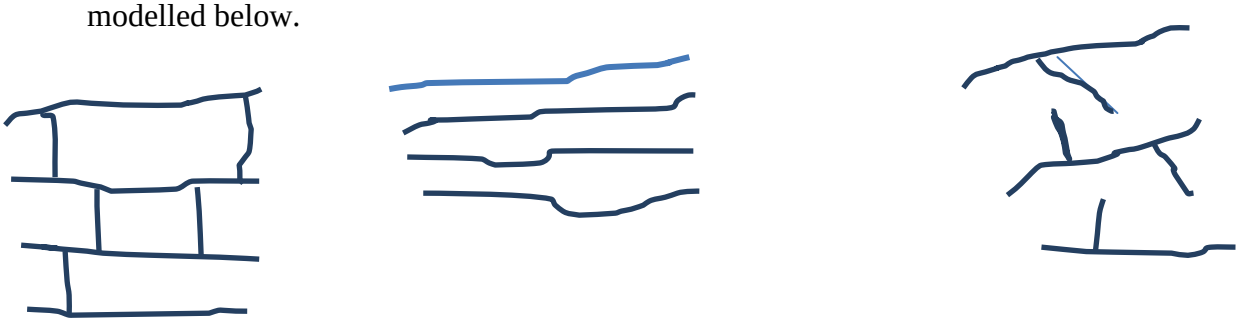
Marking allocation

- 1 mark for monomer drawn.

Explanatory notes

The monomer is chloroethene.

8c. There are many possible types of structures in polymers. Three of these types are modelled below.



A B C

i. Which of these models represents a polymer that cannot be recycled? Explain your answer.

ii. Which of these models is most likely to be that of LDPE, low density polyethene? Explain your answer.

2 + 2 = 4 marks

Solution

i. Model A cannot be recycled. It is cross-linked so covalent bonds would have to be broken to melt it. This does not happen.

ii. C is LDPE. The molecules have branches. This means they cannot pack nicely and the density is low.

Marking allocation

Part i:

- 1 mark for identifying model A.
- 1 mark for explaining the significance of cross-links.

Part ii:

- 1 mark for model C.
- 1 mark for including mention of branches.

Explanatory notes

Model A shows cross-links between the chains. This means covalent bonds hold the molecules together. They are strong bonds so the melting point is higher than non-cross-linked polymers. It also means the molecules cannot be melted and recycled.
Model C has many branches on the long chains. This means the chains cannot pack together well. The density is low if the molecules cannot pack together.

8d. Which of the following items is likely to be made from a thermoset polymer?

saucepan handle ice-cream container detergent bottle frying pan handle

1 mark

Solution

Saucepan handle and frying pan handle

Marking allocation

- 1 mark for having both answers correct.

Explanatory notes

Thermoset polymers are often more expensive and they cannot be recycled. They are only used if it is likely to be helpful and this is the case when high heat resistance is required. Cooking devices can be exposed to temperatures in excess of 200°C, making a thermoset material essential.

Total 8 marks

END OF SOLUTIONS BOOK

END OF SOLUTIONS BOOK