Westminster School

Sixth Form Entrance Examination

CHEMISTRY

Sample structured questions

The following questions are offered to give an idea to prospective candidates on the style that is used in our 6th Form Entry papers.

The first question on the entrance paper each year is compulsory for all. For the remaining questions, typically candidates will be asked to answer any three questions out of a possible five. There is no extra credit given to anyone who answers more than three questions – their highest three marks are used. Given the time pressure, it is advised that candidates answer only three.

These questions are designed to test a candidate's ability to apply their understanding of chemistry in a novel context. In many cases, it may be possible to map a question to a particular topic – e.g. if it's obviously an organic topic – but the expectation is that general chemical skills are enough to have a good go at most questions. In some cases, questions are designed to be extensions on specific GCSE topics. A number of questions contain the command word 'suggest' – this is an indication that there may well be more than one possible answer. Good application of knowledge – whether or not it is 100% correct – will always gain credit. We are looking for evidence of an ability to *apply* rather than *regurgitate* knowledge, after all.

In a typical paper, each question would be worth the same number of total marks. Questions provided in this sample document offer a variation of marks and styles to give an idea of what to expect. In a real paper, there would be standardisation of marking within each question to ensure a fair result.

Question 1

This question is about the structure of elements and compounds.

a) Carbon has two major allotropes; graphite and diamond, as well as minor ones such as those represented on the right.
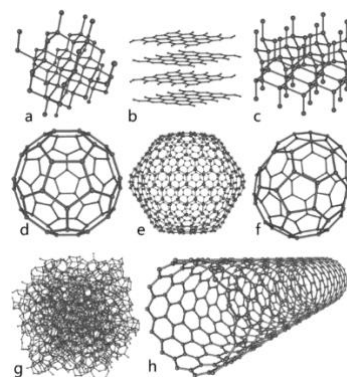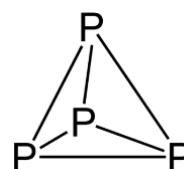
Explain what is meant by the term allotrope.

………

………

[1]

b) Phosphorus also has a number of allotropes, with each phosphorus atom forming three bonds. Two allotropes of phosphorus are represented below.

$$P\equiv P$$

Linear P_2 molecule   Tetrahedral P_4 molecule

Draw **two** more possible allotrope of phosphorus in the space below:

[2]

c) Sulphur also has many allotropes.

(i)   How many bonds will each sulphur atom form in its allotropes? The Periodic Table at the back of the paper may help you.
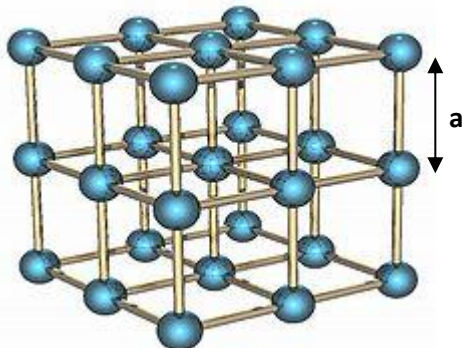
………

[1]

(ii)   In the space below, draw the structures of **two** possible allotropes of sulphur.

[2]

d) Polonium is the only metal to occur in the simple cubic arrangement shown below. In the figure below there are eight cubes of length **a**. Each cube is identical and the structure is repeated millions of times throughout a sample of polonium.

a	3.35 x 10^{-8} cm
density	9.20 g/cm^3

(i)   Calculate the volume of one of the cubes.

(ii)   By considering how a polonium atom in the corner of each cube is shared with a neighbouring cube, state how many polonium atoms are in each cube.

(iii)   Use the given density value to calculate the mass of an average polonium atom.

[4]

[Total: 10]

3

Question 2

This question is about mustard gas.

Mustard gas or sulphur mustard are names commonly used for organic compounds containing sulphur and chlorine. Such compounds are potent alkylating agents, which can interfere with several biological processes. Also known as mustard agents, this family of compounds comprises infamous cytotoxins and blister agents with a long history of use as chemical weapons.

Figure 1 - image credit militaryhistorynow.com

The structure of one such gas, dichlorodiethyl sulphide, is shown below:
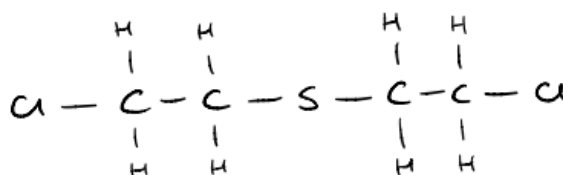
One step in the production of mustard gas involves a reaction with chlorine gas. Chlorine gas can be made via the electrolysis of aqueous sodium chloride.

a) Explain why mustard gas is classed as a saturated compound.

……

……

[1]

b) Outline a chemical test that could be used to identify the following:

(i) Chloride ions

……

……

[2]

(ii) Chorine gas

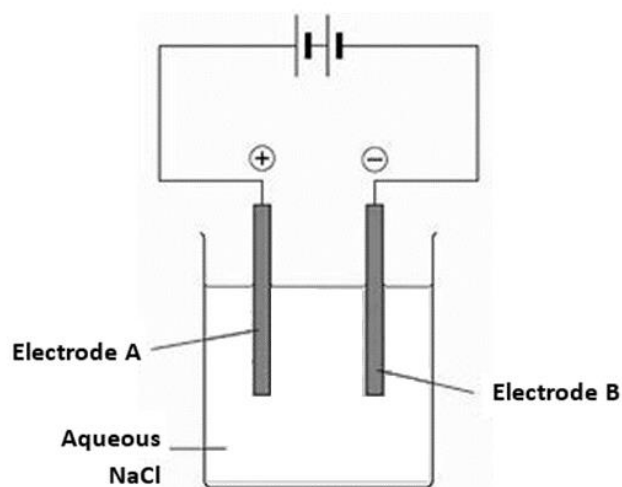……

……

[2]

4

c) A simplified diagram of the apparatus required to electrolyse brine (saturated NaCl (aq)) is shown below.

(i) State the name of **Electrode B**.

....
[1]

(ii) State at which electrode the chlorine gas would be produced.

....
[1]

(iii) Name the product that forms at the other electrode.

....
[1]

(iv) If the sodium chloride solution is very dilute another product forms at the same electrode as the chlorine. Write a half-equation to show the production of this product. You should include state symbols.

....
[3]

d) There are a number of structural isomers of dichlorodiethyl sulphide.

(i) Define the term **isomer**.

....

....

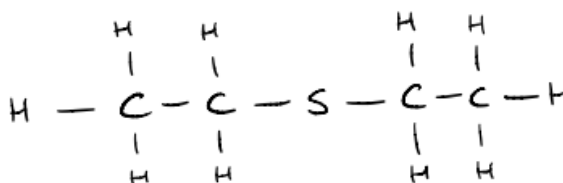...
[2]

(ii)   Draw the displayed (or skeletal) formula for another isomer of dichlorodiethyl sulphide.

[1]

e) One method to produce dichlorodiethyl sulphide involves reacting a saturated compound with chlorine. The compound used is shown below.

(i)   Name the type of reaction takes place when this compound reacts with chlorine.

    ....

[1]

(ii)   State the name or formula of the other product formed during this reaction.

    ....

[1]

(iii)   Give a necessary reaction condition.

    ....

[1]

f) Other organic compounds containing sulphur and chlorine are known to exist and the collection of these may be considered to be a homologous series. The first three members of this homologous series are shown below.
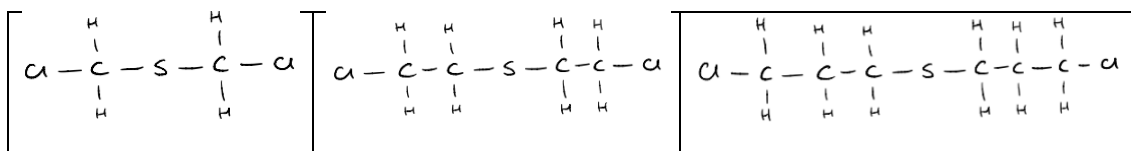
(i)   Deduce the general formula for this homologous series.

    ....

[1]

(ii) Apart from sharing a general formula, state two other characteristics of this homologous series.

………

………

………

[2]

[Total: 20]

Question 3

This question is about distinguishing between chemicals.

A prospective Westminbster chemsit has been tasked with helping with the end of year chemical stocktake but manages to remove the labels from a number of reagent bottles. They decide to carry out some chemical tests to help identify the chemicals.

Their results are tabulated below, where the letters **A – E** represent the unknown chemicals. Where a cell is greyed out, the test was not performed. Unless stated otherwise, each test was performed on a fresh sample of the unknown.

You may not be familiar with *all* of the observations but can deduce identities with what you do know.

Test number	Test	A	B	C	D
1	Addition of sodium hydroxide…	No observation	No observation	No observation	No observation
	… followed by gentle heating	Gas produced and then tested further			
2	Flame test			Orange-red flame	Apple green flame
3	Addition of silver nitrate…	No observation	No observation	White ppte	White ppte
	… followed by nitric acid	No observation	No observation	White ppte remained	Ppte disappeared with effervescence
4	Addition of sulphuric acid	No observation	No observation	White ppte	White ppte formed with effervescence

a) Identify the cation in unknown **C.**

………

[1]

b) Identify the anions present in unknowns **C** and **D** by writing their **formulae** below.

Anion in **C**	
Anion in **D**	

[2]

c) Suggest the formula for the white precipitate formed in Test 4 with unknown **D**.

………

[1]

d) Suggest the likely identity of the gas produced in Test 1 with unknown **A**. Describe a further test that could prove this.

………

………

[2]

e) The gas produced in Test 3 with unknown **D** was bubbled through the solution formed from Test 1 with unknown **C**. State what observation is likely to be made.

………

[1]

f) Unknown **B** is a colourless, organic liquid with empirical formula CH_2O. When Unknown **D** was added to it, effervescence was observed. Mixing unknown **B** with ethanol resulted in a sweet-smelling compound.

(i) State what can be deduced from the observation made from the reaction of **B** with **D**.

……

[1]

(ii) Draw the displayed formula for a possible product of the reaction between unknown **B** and ethanol.

[2]

[Total: 10]

Question 4

This question is about quantities and calculations in chemistry.

a) Complete the following table, using the Periodic Table at the back of the paper.

Symbol	Protons	Neutrons	Electrons
^{10}B	5		
$^{16}O^{2-}$			
$^{7}Li^{+}$			

[4]

b) Circle the particle below which has the same number of electrons as protons.

$^{1}H^{+}$ Cl^{-} Al P^{3-}

[1]

c) Circle the atom below in which the number of neutrons is greater than the number of protons.

^{14}N $^{4}He^{+}$ ^{13}C $^{32}S^{2-}$
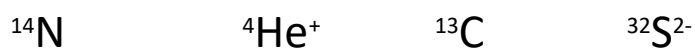
[1]

d) Which of the following is the best estimate for the size of an atom in metres.

Circle the letter that corresponds to your answer.

    A   0.001 m
    B   0.00001 m
    C 1×10^{-10} m
    D 1×10^{-15} m

[1]

e) Use the following information to answer the questions that follow.

A mole is the collective noun used to express large amounts, such that 1 mole = 6×10^{23} units (in the same way that a dozen = 12).

(i)   Which of the following contains the greatest number of hydrogen **atoms**?
    Circle the letter that corresponds to your answer.

    A   2 moles of water, H_2O
    B   1.5 moles of ammonia, NH_3
    C   1 mole of hydrogen gas, H_2
    D   0.5 moles of methane, CH_4

[1]

(ii)   How many moles of water would be produced if 1.5 moles of oxygen was reacted with excess hydrogen, according to the equation below?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

………
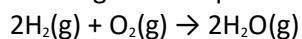
[1]

(iii)   How many **molecules** of hydrogen would have reacted in the example above?

………

[1]

(iv)   If 2g of hydrogen gas was completely reacted with 16g of oxygen (i.e. no gases left over), what mass of H_2O would be produced?

………

[1]

(v)   Outline a **chemical** test that would allow you to confirm that the product of the above reaction was indeed water.

………

………

………

[2]

f) The element sulphur is in the same Group as oxygen. Its majority is made up of three stable isotopes and has a relative atomic mass of 32.092.

Complete the following table, using the blank space to show your working. Credit will be given for an incorrect answer with some working. Give your answers to 2 decimal places.

Isotope	Abundance
^{32}S	95.02%
^{33}S	
^{34}S	

[3]

g) Livermorium is a synthetic superheavy element with symbol Lv and atomic number 116. It has not been observed in nature and has only been created in the laboratory by bombarding calcium with one other element in a particle accelerator.

(i)   In which Group of the Periodic Table is livermorium?

………

(ii)   Deduce the formula of the compound formed when livermorium reacts with hydrogen.

………

(iii)   Which element was collided with calcium to make livermorium?

………

[4]

[Total: 20]