Westminster School

Sixth Form Entrance Examination

CHEMISTRY

Sample compulsory question (Q1)

Worked Answers

Where appropriate, further information is given in each answer – for example, common mistakes and misconceptions, or where extra credit may have been awarded.

These extended notes are written in *blue*.

<u>Question One</u> – **ALL candidates should attempt this question**

This question is about basic principles in chemistry.

a) For each of the following, please **<u>circle</u>** the letter of your chosen answer. There is only **<u>one</u>** correct answer in each case.

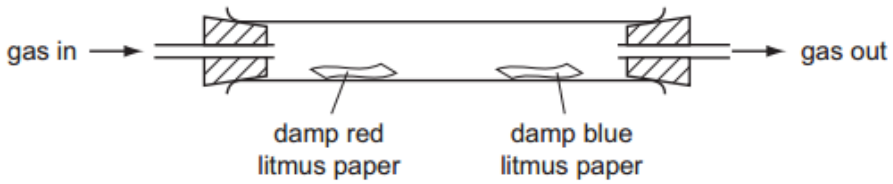
(i)	When balanced, what is the value of ***e*** in the following equation? $$\boldsymbol{a}\ C_2H_4O + Cr_2O_7^{2-} + \boldsymbol{b}\ H^+ \rightarrow C_2H_4O_2 + \boldsymbol{d}\ Cr^{3+} + \boldsymbol{e}\ H_2O$$

One approach to answering this type of question is to consider any element which is present in only one species on each side of the equation – in this case, Cr appears in the $Cr_2O_7^{2-}$ and the Cr^{3+} only. Hence *d = 2*. Similarly, *a = 1*, as carbon only appears in the organic reactant and product.

We can get *b* by considering the charge on each side of the equation – remember that charge must be conserved. This gives us *b = 8*, since LHS = 8 – 2 = +6, which is the same as the RHS (2 x +3).

Hence ***e = 4***, since the other hydrogens are balanced between the organic reactant and product.

<u>Answer: B</u>

(ii)	Four different gases are passed through the apparatus shown.  Which gas has **no** effect on either piece of litmus paper?

Red litmus turns blue in the presence of a base, and blue litmus turn red in the presence of an acid. Only hydrogen in the list will react with neither of these.

<u>Answer: D</u>

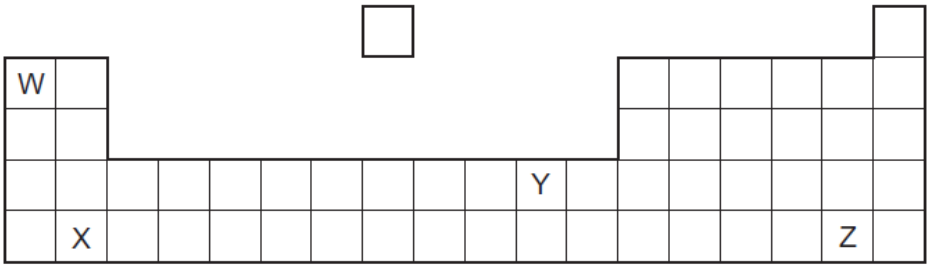
(iii)	Elements **X**, **Y** and **Z** are in group 7 of the Periodic Table. **X** is a gas; **Y** is less reactive than **Z**; and **Z** is a liquid. Which of the following gives the correct order of increasing reactivity?

In group 7, as you descend the group, the states go from gas to liquid to solid (i.e. the mp/bp increases). Hence Z is less reactive than X (since the elements at the top of group 7 are the more reactive).

This gives us that X > Z.

If Y < Z, we can get that the order of reactivity must be X > Z > Y.

<u>Answer: B</u>

(iv)	The positions of elements W, X, Y and Z in the Periodic Table are shown.  Which elements form basic oxides?

Basic oxides are metal oxides, so this question is simply about spotting which of the elements in the table are metals – W, X and Y.

Answer: A

(v)	Which atom has twice as many neutrons as protons?

The superscript number is the mass number (protons + neutrons) and the subscript is the atomic number (protons).

$^{3}_{1}H$ has 1 proton and therefore, 3-1 = 2 neutrons.

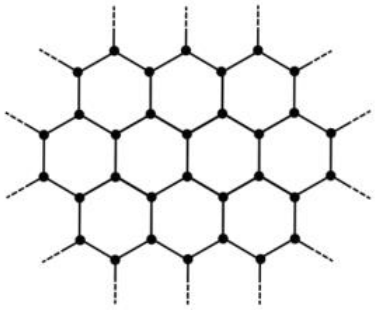
Answer: C

(vi)	Which of the following have the same electronic configuration? **1** $^{35}_{17}Cl^{-}$ (18e$^-$) **2** $^{36}_{17}Cl^{+}$ (16e$^-$) **3** $^{40}_{18}Ar$ (18e$^-$) **4** $^{39}_{19}K^{+}$ (18e$^-$) **5** $^{40}_{20}Ca^{+}$ (19e$^-$) **6** $^{41}_{19}K^{-}$ (20e$^-$)

The easiest route to the answer here is to recognise that if species have the same electronic configuration then they must have the same number of electrons. A negative charge means that the species has 1 extra electron compared to protons, while a positive charge indicates one fewer electrons than protons.

Answer: C (1, 3 and 4)

(vii)	Graphene is a new material composed of carbon atoms arranged in tightly bound hexagons just one atom thick.

	The diagram shows a simplified structure of graphene.  Considering its structure, which of the properties below could be predicted about graphene? **1.** High melting point **2.** Good electrical conductivity **3.** Soluble in water

We can see from the structure that the structure is giant so we should expect graphene to have a high melting point. Since it is giant covalent, it shouldn't be soluble in water.

We see only single bonds in the structure so it can be deduced that there must be delocalised electrons – hence we should expect it to conduct electricity.

Answer: B (1 and 2)

(viii)	A metal, **X**, is in group 3 of the Periodic Table. A non-metal, Y, is in group 6 of the Periodic Table. They react together to form a compound. What is the formula of the compound?

A group 3 metal will form ions of 3+ charge. Non-metals in group six form ions with 2- charge. Hence a compound of the two will have the formula X_2Y_3.

Answer: B

(ix)	Magnesium hydrogen phosphate contains the following ions: Mg^{2+}, H^+ and PO_4^{3-}. Which one of the following is a possible formula for magnesium hydrogen phosphate?

Trial and error is one approach here. The correct answer is $Mg(H_2PO_4)_2$, which we can see by looking at the charge of the component in the bracket: 2(+1) – 3 = -1. Hence two of these are needed to balance the 2+ charge of a magnesium ion.

Answer: B

(x)	Naturally occurring chlorine is a mixture of two isotopes with mass number 35 and 37. The isotope with mass number 35 is three times as common as the isotope with mass number 37. Naturally occurring bromine is a mixture of two isotopes with mass numbers 79 and 81. They are present in equal amounts.

	What fraction of the naturally occurring compound CH_2BrCl has a relative molecular mass of 128? *[The relative molecular mass of a compound is the sum of its atomic masses]*.

From the information we get that Cl-35 is 75% abundant (3/4), and Cl-37 is 25% abundant (1/4). Br-79 and Br-81 are both 50% abundant (1/2).

To make CH_2BrCl with a mass of 128 , we require Br-79 and Cl-35 and (12 + 1 + 1 + 79 + 35= 128). Its abundance will therefore be ½ x ¾ = 3/8.

Answer: C

b) Give the chemical formulae of the following substances:

(i) Magnesium chloride

$MgCl_2$

(ii) Magnesium hydroxide

$Mg(OH)_2$

(iii) Nitric acid

HNO_3

(iv) Sulphuric acid

H_2SO_4

[4]

c) Write **balanced chemical equations** for the following processes. State symbols are **not** required.

1 mark for correct species, 1 mark for balancing (ecf on formulae from above for the balancing mark)

(i) The neutralization of magnesium hydroxide with sulphuric acid.

$Mg(OH)_2 + H_2SO4 \rightarrow MgSO_4 + 2H_2O$

(ii) The reaction of magnesium metal with hydrochloric acid.

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

(iii) The reaction of magnesium carbonate with nitric acid.

$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + CO_2 + H_2O$

[6]

[Total for Q: 20 marks]