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CHEMISTRY

PHYSICAL CHEMISTRY

LEVEL & BOARD:	OCR (AS- LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	QUESTION PAPER 1
TOTAL QUESTIONS	10
TOTAL MARKS	52

Amount of Substance

1. This question is about several salts. A hydrated salt, compound A, is analysed and has the following percentage composition by mass:

Cr 19.51%
Cl 39.96%
H 4.51%
O 36.02%

Calculate the formula of compound A, showing clearly the water of crystallisation. Show your working. [3]

2. By 2020, the EU has regulated that a car must emit less CO_2 per kilometre than in 2015. A typical car will need to emit 5.6×10^5 g less CO_2 in 2020 compared with 2015.

Calculate how much less petrol would be consumed by a typical car in 2020 to meet this regulation.

Give your answer in litres of petrol (1 litre of petrol has a mass of 700 g).

Assume that petrol is liquid octane and that complete combustion takes place, as in the equation below.

C_8H_{18} (l) + $12.5O_2$ (g) → $8CO_2$ (g) + $9H_2O$ (l) [4]

3. Nitrogen forms several different oxides. N_2O is a useful anaesthetic and NO has been linked to the depletion of ozone in the stratosphere. N_2O is supplied as a compressed gas in steel cylinders for use as an anaesthetic. The cylinders are stored at 20.0 °C.

Calculate the gas pressure, in Pa, in a 2.32 dm^3 steel cylinder containing 187 g of N_2O gas. Give your answer in standard form to three significant figures. [4]

4. Group 2 elements are metals that react with oxygen and water.

(a) A student reacts a Group 2 metal, M, with water.

$M(s) + 2H_2O(l) \rightarrow M(OH)_2(aq) + H_2(g)$

The student measures the volume of hydrogen gas produced. 0.162 g of the metal produces 97.0 cm^3 of gas measured at room temperature and pressure.

i. Draw a labelled diagram of the apparatus that can be used to carry out this experiment. [2]

ii. Identify the Group 2 metal, M. Show your working. [3]

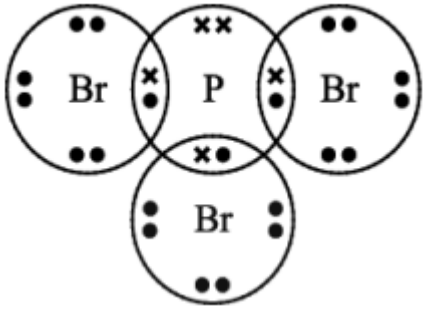
(b) The student plans to repeat the experiment using the same mass of a Group 2 metal from further down the group. Predict whether the volume of hydrogen produced would be greater than, less than or the same as the volume in the first experiment. Explain your answer. [1]

5. Bromine is a reactive element. It combines with other non-metals to form covalent compounds. Phosphorus tribromide, PBr_3, and iodine monobromide, IBr, are examples of covalent compounds used in organic synthesis. PBr_3 can be prepared by heating bromine with phosphorus, P_4

(a) Write an equation for this reaction. [1]

(b) How many molecules are present in 1.3535 g of PBr_3? [3]

(c) The 'dot-and-cross' diagram of a molecule of PBr_3 is given below



Name the shape of this molecule and explain why the molecule has this shape. [3]

6. When hydrated strontium chloride is heated, the water of crystallisation is removed, leaving a residue of anhydrous strontium chloride.

A student carries out an experiment to find the value of x in the formula of hydrated strontium chloride, $SrCl_2.xH_2O$.

The student's method is outlined below.

Step 1 Weigh an empty crucible. Add $SrCl_2.xH_2O$ to the crucible and reweigh.

Step 2 Heat the crucible and contents for 10 minutes. Allow to cool and reweigh. Step 3 Heat the crucible and residue for another 5 minutes. Allow to cool and weigh the crucible and residue. Repeat step 3 a further two times. The student's results are shown below:

Mass of empty crucible / g	15.96
Mass of crucible + $SrCl_2.xH_2O$ / g	18.65
First mass of crucible + residue / g	17.66
Second mass of crucible + residue / g	17.61
Third mass of crucible + residue / g	17.58
Fourth mass of crucible + residue / g	17.58

(a) Calculate the value of x in $SrCl_2.xH_2O$. Give your answer to 2 significant figures. [3]

(b) Suggest why the student takes four readings of the mass of the crucible and residue. [1]

(c) Suggest two modifications to the method that would reduce the percentage uncertainty in the mass of the residue. [2]

7. This question is about compounds used in fertilisers. A compound used as a fertiliser has the following composition by mass:

C 20.00%
H 6.67%
N 46.67%
O 26.66%

Calculate the empirical formula of this compound. [2]

8. In an experiment, a scientist prepared a 0.500 g sample of a salt made by neutralisation. Analysis of the sample gave the following data.

Element	Mass present / g
hydrogen	0.025
oxygen	0.300
nitrogen	0.175

(a) Calculate the empirical formula of the salt. [2]

(b) Suggest the formula of the acid and base that the scientist used to prepare this salt. [1]

9. N_2O_3 reacts with water to form an acid as the only product.

(a) This reaction is not a redox reaction. The empirical formula of the acid formed is the same as the molecular formula.

i. State what is meant by the term molecular formula. [1]

ii. Suggest the empirical formula of the acid formed. [1]

(b) Calculate the amount, in mol, of nitrogen atoms in 5.117×10^{20} nitrogen molecules. [2]

10. This question is about compounds of magnesium and phosphorus.

(a) A student plans to prepare magnesium phosphate using the redox reaction of magnesium with phosphoric acid,

H_3PO_4. $3Mg(s) + 2H_3PO4(aq) \rightarrow Mg_3(PO_4)_2(s) + 3H_2(g)$

i. In terms of the number of electrons transferred, explain whether magnesium is being oxidised or reduced. [1]

ii. The student plans to add magnesium to 50.0 cm^3 of 1.24 mol dm^{-3} H_3PO_4.Calculate the mass of magnesium that the student should add to react exactly with the phosphoric acid. Give your answer to three significant figures. [3]

iii. How could the student obtain a sample of magnesium phosphate after reacting magnesium with phosphoric acid? [2]

iv. Magnesium phosphate can also be prepared by reacting phosphoric acid with a compound of magnesium. Choose a suitable magnesium compound for this preparation and write the equation for the reaction. Formula of compound Equation [2]

(b) Phosphine, PH_3, is a gas formed by heating phosphorous acid, H_3PO_3, in the absence of air.

$4H_3PO_3(s) \rightarrow PH_3(g) + 3H_3PO_4(s)$

i. 3.20×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction. Calculate the volume of phosphine gas formed, in cm^3, at 100 kPa pressure and 200 °C. [4]

ii. When exposed to air, phosphine spontaneously ignites, forming P_4O_{10} and water. Construct an equation for this reaction. [1]

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