CHEMISTRY ONLINE
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CHEMISTRY

PHYSICAL CHEMISTRY

Level & Board	AQA (A-LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	SOLUTION - 1
TOTAL QUESTIONS	10
TOTAL MARKS	/42

Amount of Substance - 1

1. C

(1)

2.

(a)

The masses of the elements in this sample are:

- Sodium (Na): 21.6 g
- Chlorine (Cl): 33.3 g
- Oxygen (O): 45.1 g

Convert the masses to moles:

- Moles of Na: 21.6g / 22.99 g/mol=0.939 mol
- Moles of Cl: 33.3g / 35.45 g/mol=0.94 mol
- Moles of O: 45.1 g / 16.00 g/mol=2.82 mol

Determine the mole ratio of the elements:

- Ratio of Na: 0.939 / 0.939 = 1
- Ratio of Cl: 0.94 / 0.939 = 1
- Ratio of O: 2.82 / 0.939 = 3

Write the empirical formula:

The simplest whole number ratio of Na : Cl : O is 1 : 1 : 3.

So , the empirical formula of sodium chlorate(V) is $NaClO_3$.

(3)

(b)

Balanced equation:

$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

(1)

3.

(a)

Determine the mass of water lost:

Mass of water=Initial mass of hydrated salt−Mass of anhydrous salt

Mass of water=2.287 g−1.344 g=0.943 g

Calculate the moles of anhydrous $NiSO_4$:

Molar mass of $NiSO_4$:

Ni=58.69 g/mol,
S=32.07 g/mol,
O × 4 =4×16.00 g/mol=64.00 g/mol

Molar mass of $NiSO_4$=58.69+32.07+64.00
=154.76 g/mol

Moles of $NiSO_4$:

Moles of $NiSO_4$ =1.344 g / 154.76 g/mol=0.008684 mol

Calculate the moles of water:

Molar mass of H_2O =18.02 g/mol

Moles of water:

Moles of water=0.943 g / 18.02 g/mol =0.05232 mol

Determine the value of x:

x=Moles of water / Moles of $NiSO_4$

=0.05232 mol / 0.008684 mol=6.02

The value of x in $NiSO_4 \cdot 6H_2O$

(4)

(b)

Heat to constant mass

Reheat the sample.

Check that the mass is unchanged after reheating and cooling until the mass remains constant.

Or

Infrared Spectroscopy (IR)

Record an IR spectrum.

Check for the absence of a peak between 3230 and 3550 cm^{-1}, indicating no water is present.

(2)

4. B

(1)

5.

(a)

Equation for the reaction between iron and dilute sulfuric acid:

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

(1)

(b)

Chemical Hazard:

Sulfuric acid is corrosive.
Hydrogen gas is flammable/explosive.

Safety Precaution:
For sulfuric acid:
Wear gloves and eye protection to prevent skin and eye contact.
For hydrogen gas:
Avoid naked flames or sparks to prevent ignition and potential explosions.

(2)

6. B

(1)

7.

I am Sorry !!!!!

(a)

Mass of water lost:

Mass of water lost = 4.38 g − 2.46 g = 1.92 g

Moles of anhydrous zinc sulfate:

Molar mass of $ZnSO_4$=161.45 g

Moles of $ZnSO_4$=2.46 g / 161.45 g/mol = 0.01523 mol

Moles of water:
Molar mass of H_2O=18.02 g/mol
Moles of H_2O=1.92 g / 18.02 g/mol=0.1065 mol

Value of x:
x=0.1065 mol / 0.01523 mol = 7
so, x is 7, so the formula is $ZnSO_4 \cdot 7H_2O$

(3)

(b)

Moles of HCl = 1.20mol/dm^3×0.100dm^3 =0.120mol

Moles of ZnO=0.0830 mol

Required moles of HCl=0.0830 mol×2=0.166 mol

As we have only 0.120 mol of HCl, HCl is the limiting reagent.

Moles of $ZnCl_2$=0.120 mol / 2 =0.060 mol

Molar mass of $ZnCl_2$=65.4+2×35.5=136.4 g/mol

Mass of $ZnCl_2$=0.060 mol×136.4 g/mol=8.18 g

(4)

(c)
Calculate moles of $ZnCl_2$

Moles of $ZnCl_2$=10.7 g / 136.4 g/mol=0.0784 mol

Determine moles of zinc reacting:

As 1 mole of Zn produces 1 mole of $ZnCl_2$:

Moles of Zn=0.0784 mol

Calculate the mass of zinc reacting:

Mass of Zn=0.0784 mol×65.4 g/mol=5.13 g

Calculate the percentage purity:

Percentage purity=(5.13g / 5.68g)×100=(5.685.13)×100

=90.3%

(4)

(d)

Ionic

Solid zinc fluoride (ZnF_2) forms an ionic crystal structure.

Reason for High Melting Point

The high melting point of zinc fluoride is due to:

Strong Electrostatic Attraction

There is a strong electrostatic attraction between the oppositely charged ions, specifically between the Zn^{2+} ions and the F^- ions.

This strong ionic bonding results in a high melting point for zinc fluoride, as a significant amount of energy is required to overcome these forces and break the crystal lattice.

(3)

I am Sorry !!!! **8.**

(a)

Calculate moles of $Cr_2O_7^{2-}$ per titration:

- Volume of $K_2Cr_2O_7$ solution used = 21.3 cm^3

- Concentration of $K_2Cr_2O_7$ solution = 0.0150 mol/dm^3
- Moles of $Cr_2O_7^{2-}$ used = concentration × volume
- Moles of $Cr_2O_7^{2-}$ =(21.3×0.0150)/1000=3.195×10^{-4} mol

Calculate moles of Fe^{2+}:

- According to the balanced equation

  $Cr_2O_7^{2-}+14H^++6Fe^{2+}\rightarrow2Cr^{3+}+7H_2O+6Fe^{3+}$

  the ratio of $Cr_2O_7^{2-}$ to Fe^{2+} is 1:6.

- Moles of Fe^{2+} reacted:
- Moles of Fe^{2+}=6×3.195×10^{-4}=1.917×10^{-3} mol

Calculate original moles of Fe^{2+} in 250 cm^3 solution:

- The solution was diluted to 200 cm^3 after titration, but initially, it was 250 cm^3.
- Moles of Fe^{2+} in 250 cm^3:
- Moles of Fe^{2+} $= \frac{1.917\times10^{-3}\times10}{250/1000}$ = 1.917×10^{-2} mol

Calculate mass of $FeSO_4\cdot7H_2O$

Molar mass of $FeSO_4\cdot7H_2O$ = 278.9 g/mol

- Mass of $FeSO_4\cdot7H_2O$
- Mass=Moles×Molar mass=1.917×10^{-2}×278.9=5.33 g

So, the mass of $FeSO_4\cdot7H_2O$ obtained is **5.33 g**,

(5)

(b)

Impurity:

Reducing Agent or Partially Hydrated Compound

Reducing Agent:

- An impurity that is a reducing agent would react with the dichromate ($Cr_2O_7^{2-}$) during titration.

- *This causes the impurity to react with more dichromate than the same mass of $FeSO_4 \cdot 7H_2O$, leading to an overestimation of the moles of Fe^{2+}.*

Partially Hydrated Compound:

- *An impurity that is a version of $FeSO_4$ with fewer than 7 waters of hydration has a higher concentration of Fe^{2+} per unit mass.*
- *For equal masses, this impurity reacts with more dichromate than $FeSO_4$, resulting in an overestimated calculation of the $FeSO_4 \cdot 7H_2O$ mass.*

So, the impurity makes the calculated mass of $FeSO_4 \cdot 7H_2O$ appear greater than the actual mass.

(2)

9. **C**

(1)

10.

Molar mass of BaO:
BaO=153 g/mol

Determine the moles of BaO in 500 g:
500 g / 153 g/mol =3.268 mol =3.268mol

Use the stoichiometry from the balanced equation

($6BaO + 2Al \rightarrow 3Ba + Ba_3Al_2O_6$):

6 mol BaO→3 mol Ba⇒1 mol BaO→1/2 mol Ba

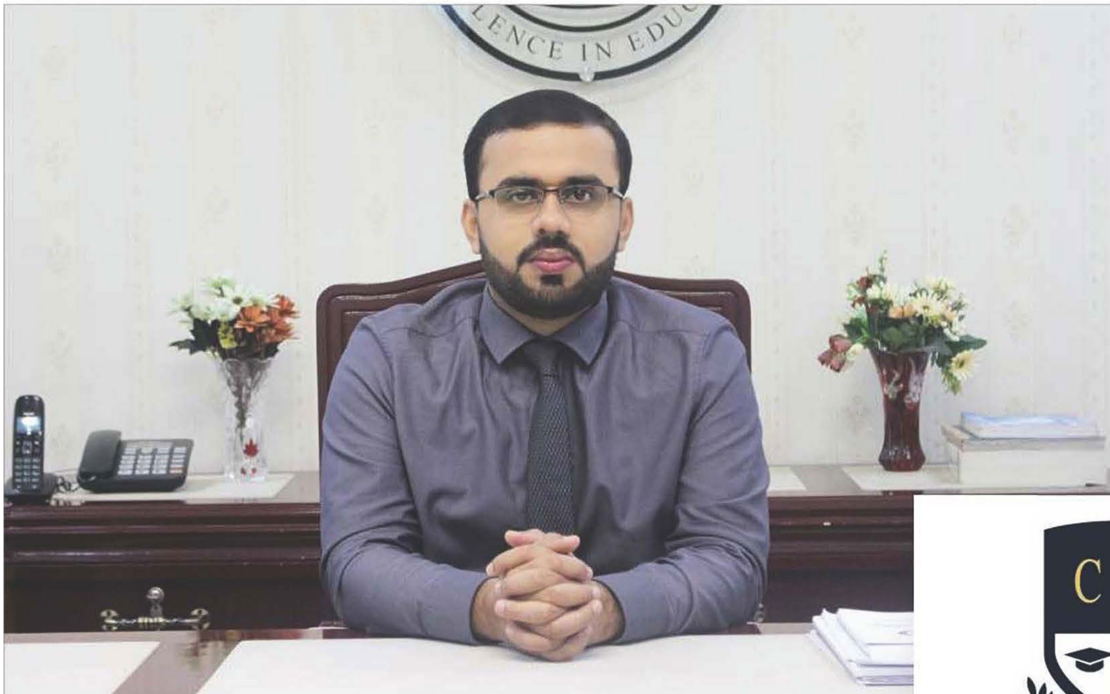
Moles of Ba=(3.268 mol BaO) / 2 =1.634 mol Ba

moles of Ba to grams:

1.634 mol Ba×137 g/mol=223.86 g Ba

I am Sorry !!!!!

(4)



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