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CHEMISTRY

PHYSICAL CHEMISTRY

Level & Board	AQA (A-LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	SOLUTION - 2
TOTAL QUESTIONS	10
TOTAL MARKS	/38

Amount of Substance - 2

1.

Given:

- Amount of CaS = 2.50 g
- Amount of $CaSO_4$ = 9.85 g
- Molar masses:
  - Molar mass of CaS (CaS) = 72.2 g/mol
  - Molar mass of $CaSO_4$ ($CaSO_4$) = 136.2 g/mol

Calculate moles of CaS and $CaSO_4$

Moles of CaS:
Moles of CaS=2.50 g / 72.2 g/mol=0.0346 mol

Moles of $CaSO_4$:
Moles of $CaSO_4$=9.85 g / 136.2 g/mol=0.0723 mol

Determine the limiting reagent

According to the balanced equation:

$CaS+3CaSO_4 \rightarrow 4CaO+4SO_2$

So 1 mole of CaS requires 3 moles of $CaSO_4$.

Moles of $CaSO_4$ required for CaS:

0.0346 mol CaS×3=0.1038 mol $CaSO_4$

Since we only have 0.0723 mol of $CaSO_4$, it is the limiting reagent.

Calculate moles of SO_2 formed

From the limiting reagent ($CaSO_4$), calculate moles of SO_2 produced:

Moles of SO_2=(0.0723mol $CaSO_4$)× 4 mol SO_2 / 3 mol $CaSO_4$
=0.0964mol SO_2

Calculate mass of SO_2 formed

Mass of SO_2=0.0964 mol×64.1 g/mol=6.18 g

So, the mass of sulfur dioxide (SO_2) formed in the reaction is 6.18 g.

(5)

2. C (1)

3.

(a)

Given titration results:
Rough: 20.85 cm^3
Titration 1: 20.25 cm^3
Titration 2: 20.50 cm^3
Titration 3: 20.30 cm^3

Mean titre value:
Mean titre=(20.25+20.50+20.30)/3
=61.05/3
=20.35 cm^3

Calculate moles of NaOH:

Moles of NaOH=0.350 mol/dm^3×(20.35 cm^3 / 1000 cm^3/dm^3)

Moles of NaOH=0.350×0.02035=0.007125 mol

Moles of ethanoic acid in 25 cm^3:

Moles of CH_3COOH=Moles of NaOH=0.007125 mol

Moles of ethanoic acid in 200 cm^3:

Moles of CH_3COOH in 200 cm^3=0.007125 mol×8=0.05698 mol

Mass of CH_3COOH=0.05698mol×60.05g/mol=3.420g

Mass of CH3COONa=5.60−3.419=2.181g

Percentage by mass of CH_3COONa=(5.60 / 2.181)×100=38.95%

(6)

(b)

Effect of Rinsing Burette with Deionised Water

The titre value would increase. Because the sodium hydroxide solution would be more dilute.

(2)

4. **B**

(1)

5. This question is about two experiments on gases.

(a)

Pressure:
51.0 kPa = 51,000 Pa

Volume:
482 cm^3 =0.000482 m^3

Calculate moles (n):

$$n = \frac{\text{PV}}{\text{RT}}$$

$$n = \frac{51{,}000 \times 0.000482}{8.31 \times 297}$$

n= 0.00995 mol

Mass of Y = 0.717 g

Mr=mass / moles=0.717 / 0.00995=72.06

I am Sorry !!!!!

(5)

(b)

Given:
Moles of O_2 used: 0.0075mol (As half of 0.02000.02000.0200 mol of O_2 was used)
Moles of CO_2 produced: 0.0080 mol
Calculation:
Total moles of gas in the flask:
Total moles=Moles of O_2+Moles of CO_2
Total moles=0.0075 mol+0.0080 mol
=0.0155 mol

(2)

6. C

(1)

7.
(a)
Given data:
- Pressure of gas (P) = 100 kPa = 100,000 Pa
- Volume of gas (V) = 178.0 cm^3 = 0.178 L = 0.178×10^{-3} m^3
- Temperature (T) = 120 °C = 120 + 273.15 = 393.15 K
- Mass of liquid A injected = 0.460 g

  Gas constant (R) = 8.31 J K^{-1} mol^{-1}

Volume to cubic meters (m^3):

V=0.178 L=0.178×10^{-3} m^3

Calculate the number of moles of gas (n) using the ideal gas law:

$$n = \frac{\mathrm{PV}}{\mathrm{RT}}$$

$$n = \frac{100{,}000 \times 0.178 \times 10^{-3}}{8.31 \times 393.15}$$

=0.00545mol

Molecular mass (Mr) of liquid A:

Mr=Mass of liquid A / Number of moles of gas

Mass of liquid A=0.460 g=0.460×10^{-3} kg
Mr=0.460×10^{-3} kg /0.00545 mol

Mr=84.40

(4)

(b)

When some of the liquid injected into the gas syringe does not vaporize completely:

Effect on Mr Calculation:

The calculated Mr will be higher than the actual Mr of the volatile liquid A. This is because the moles of gas used in the calculation (denominator in Mr = mass / moles) are underestimated. The presence of non-vaporized liquid means the measured mass includes both vaporized and non-vaporized components, but only the vaporized portion contributes to the moles of gas.

Systematic Error:

The presence of non-vaporized liquid introduces a systematic error where the calculated Mr is inflated.
This error arises because the calculation assumes complete vaporization, but in reality, some liquid remains unvaporized, skewing the relationship between measured mass and moles of gas.

Experimental Precision:

To ensure accurate Mr determination, it's crucial that all injected liquid vaporizes completely.

Any residual liquid not vaporized compromises the accuracy of the experiment, leading to an overestimated Mr due to fewer moles of gas being accounted for in the calculation.

(2)

(c)

Total uncertainty=2×0.001g=0.002g

Percentage uncertainty= (0.002 g / 0.460 g)×100%

=0.435%

(1)

8. C

(1)

9.

Given:

- Yield of methylpropanal = 552 mg = 0.552 g
- Organic starting material used = 1.00 g
- Molar mass of methylpropanal ($C_4 H_8 O$) = 72 g/mol

Moles of reactant:

Moles of reactant=1.00 / 116 = 0.00862 mol

Calculate moles of product (methylpropanal):

Moles of methylpropanal=0.552 g / 72 g/mol=0.00767 mol

Theoretical yield=0.00862mol×72g/mol=0.62064g

Percentage yield=(0.552g / 0.62064g)×100%=88.9%

Calculate the percentage atom economy:

Percentage atom economy=(72 g / mol108 g/mol)×100%=66.7%

Percentage Yield:
Ensures efficient conversion of reactants into products, maximizing product output.

Percentage Atom Economy:
Ensures most of the reactant mass ends up in the desired product, minimizing waste and by-products.

(6)

10. B

(1)