CHEMISTRY ONLINE
— TUITION —

Phone: +442081445350

www.chemistryonlinetuition.com

Email:asherrana@chemistryonlinetuition.com

CHEMISTRY

PHYSICAL CHEMISTRY

Level & Board	AQA (A-LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	SOLUTION - 3
TOTAL QUESTIONS	10
TOTAL MARKS	/43

Amount of Substance - 3

1.

(a)

Mass of X injected
=Mass of hypodermic syringe filled with X before injection−Mass of hypo dermic syringe with left over X after injection

Given data:

Mass of hypodermic syringe filled with X before injection = 10.340 g
Mass of hypodermic syringe with left over X after injection = 10.070 g

Mass of X injected=10.340 g−10.070 g=0.270 g

Table 1

Mass of hypodermic syringe filled with X before injection / g	10.340
Mass of hypodermic syringe with left over X after injection / g	10.070
Mass of X injected / g	0.270 g

Volume of X:

Volume of X=Volume of X in gas syringe after injection−Volume reading o n gas syringe before injection of X

Volume reading on gas syringe before injection of X = 0.0 cm^3
Volume of X in gas syringe after injection of X = 105.0 cm^3
Volume of X=105.0 cm^3−0.0 cm^3=105.0 cm^3

Table 2

Volume reading on gas syringe before injection of X / cm^3	0.0
Volume of X in gas syringe after injection of X / cm^3	105.0
Volume of X / cm^3	105.0

(1)

(b)

Using the Ideal Gas Law:
PV=nRT

Given:

$P=100\ kPa=100\times10^3\ Pa$
$V=105.0\ cm^3=105.0\times10^{-6}\ m^3$

$R=8.31\ J\ K^{-1}\ mol^{-1}$
$T=97°C=370.15\ K$
Calculate $n=PV/RT$

$$n=\frac{100\times10^3\times105.0\times10^{-6}}{8.31\times370.15}$$

$n=10.5\ /3072.5465$
$n=3.41\times10^{-3} mol$

Calculation of Mr:

Using the mass of X injected:
Mr=mass of X injected / n

Mass of X injected = 0.270 g
$n=\ 3.41\times10^{-3}\ mol$

$Mr=0.270\ g\ /\ 3.41\times10^{-3}\ mol$
$Mr=79.1\ g/mol$

Identity of X:

Comparing the calculated Mr to the molar masses of the given chloroalkanes:

- CCl_4 Mr= 154g/mol
- $CHCl_3$ Mr= 119.5g/mol
- CH_2Cl_2 Mr= 85g/mol
- CH_3Cl Mr= 50.5g/mol

The calculated Mr of 79.1 g/mol is closest to the molar mass of CH_2Cl_2 (85 g/mol).

(5)

(c)

Air Leakage into the Syringe

Reason:

The volume of the gas in the syringe (V) is greater than the true volume because some air leaked into the syringe.

Effect on Calculation:
If V is too large, the calculated $Mr = m \cdot RT / PV$ would be too small because the number of moles (n) would be overestimated.

(2)

(d)
Carry out the experiment in a fume cupboard.

Reason:

To avoid exposure to toxic vapors.
This precaution helps to ensure that harmful vapors are contained and safely vented away, protecting the student's health.

(2)

2. D

(1)

3.
(a)
mass of Ni = 2.0g
moles of Ni = 2.0/58.7 mol = 0.0341mol

(2)

(b)

Number of atoms of Ni = $6.02 \times 10^{23} \times 0.0341$

$= 2.05 \times 10^{22}$ atoms

(1)

4.

Pipette

Given:

Absolute error: ± 0.05 cm^3

Measured volume: 25.0 cm^3 (typical volume for a pipette)

Calculate the percentage error:

Percentage error for pipette=(0.05 cm^3 / 25.0 cm^3)×100=0.2%

Burette

Given:

Absolute error: ± 0.15 cm^3

Average titre (measured volume): 24.25 cm^3

Calculate the percentage error:

Percentage error for burette=(0.15 cm^3 /2 4.25 cm^3)×100=0.618

(2)

5.

$P_4 + 6Br_2 \longrightarrow 4PBr_3$

(1)

6.

(a)

Balanced equations:

$4CuFeS_2 + 9\ ½\ O_2 + 7SiO_2 \longrightarrow Cu_2S + .Cu_2O + 7SO_2 + 4FeSiO_3$

$Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$

(2)

(b)

Sulfur dioxide (SO_2) by-product is removed from the exhaust gases in copper production from $CuFeS_2$ to:

Prevents Acid Rain:

- SO_2 contributes to acid rain formation when it reacts with water vapor in the atmosphere, leading to environmental damage.

Health and Safety:

- SO_2 is toxic and can cause respiratory issues and exacerbate lung conditions in humans.

(2)

(c)

Calculate the percentage of copper in $CuFeS_2$:

The molar mass of copper (Ar Cu) is 63.5 g/mol.
The molar mass of $CuFeS_2$ (Mr CuFeS2) is 183.5 g/mol.
Percentage of Cu in $CuFeS_2$=(63.51/183.5)×100=34.6%

Calculate the percentage of copper in the rock:

Given that the rock sample contains 1.25% $CuFeS_2$ by mass, we calculate the percentage of copper in the rock as follows:

Percentage of Cu in the rock=(34.6/100)×1.25=0.4325%

Calculate the mass of rock needed:

We need 4050 kg of copper.
Mass of rock=(4050×100) /0.4325

Mass of rock=405000/0.4325

Mass of rock=936416 kg

Convert mass of rock to tonnes:

Knowing 1 tonne = 1000 kg,

Mass of rock in tonnes=936416/1000

Mass of rock in tonnes=936 tonnes

(4)

(d)

Atom economy

=(Molar mass of useful products / Total molar mass of reactants)×100

Total molar mass of reactants:
2 moles of CuO + 1 mole of C
Total molar mass of reactants = 2 ×\times× 79.5 g/mol + 12.0 g/mol = 171 g/mol
Molar mass of useful products:
2 moles of Cu
Molar mass of useful products = 2 ×\times× 63.5 g/mol = 127 g/mol

Atom economy

=(127 g/mol171 g/mol)×100
Atom economy =0.74269006×100
=74.3%

(2)

7. B

(1)

8.
(a)
PV=nRT
$R=8.31 J\ K^{-1} mol^{-1}$
P=102000 Pa
$V=0.072\ m^3$
T=373 K
n=102000×0.072 / 8.31×373
n=7344 / 3105.03
$n=2.3665\times10^{-3}$ mol

Mr=mass/moles
Mr=0.000194 kg / 2.3665×10−3 mol
Mr=0.000194 / 0.0023665
Mr=82.08

(5)

(b)
Given:

- Carbon (C) is 83.7% by mass
- Hydrogen (H) is 16.3% by mass

Calculate the moles:

- Moles of carbon = 83.712.0\12.083.7 = 6.975
- Moles of hydrogen = 16.31\1.018=16.3
- Moles of carbon=6.975/6.975=1
- Moles of hydrogen≈16.3/6.975=2.34
- Carbon: C_3
- Hydrogen: H_7

So, the empirical formula of Y is C_3H_7

Ratio of Mr to EFM:

Ratio=Mr/EFM=86.0 / 43.0=2
Molecular formula=Empirical formula×Ratio
$=C_3H_7 \times 2$
Molecular formula=C_6H_{14}

(4)

9.

(a)

Volume of NaOH used = 25.30 cm³ = 25.30×10^{-3} L (converted from cm³ to L)
Concentration of NaOH (C) = 0.500 mol/dm³ = 0.500 mol/L
Amount of NaOH = Concentration × Volume
Amount of NaOH=$0.500 \times 25.30 \times 10^{-3}$
Amount of NaOH=0.01265 mol

From the balanced equation:
$H_2C_2O_4(aq) + 2NaOH(aq) \longrightarrow Na_2C_2O_4(aq) + 2H_2O(l)$
Moles of $H_2C_2O_4$ = Moles of NaOH / 2
Moles of $H_2C_2O_4$=0.01265/2
=0.006325 mol
Molar mass of $H_2C_2O_4$=90.04 g/mol

Mass of $H_2C_2O_4$ = Moles × Molar mass Mass of $H_2C_2O_4$=0.006325×90.04
= 0.5694g
Or =569.4 mg

(4)

(b)

Rinsing with deionised water ensures that all ethanedioic acid and sodium hydroxide are fully transferred into the reaction mixture, preventing residues on the flask's sides that could lead to incomplete reactions or inaccurate measurements.

Thus, it improves the accuracy of the titration by ensuring complete reaction and reliable endpoint detection.

(1)

(c)
Concordant titres refer to volume measurements in titration experiments that are within a narrow range of each other, typically within 0.1 cm^3.
This range accounts for the precision of the measuring apparatus, ensuring consistent and reliable results despite minor variations in individual readings.

(1)

10. D

(1)

DR. ASHAR RANA

CHEMISTRY ONLINE TUITION

Phone: +442081445350
www.chemistryonlinetuition.com
Email: asherrana@chemistryonlinetuition.com

- Founder & CEO of Chemistry Online Tuition Ltd.
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CONTACT INFORMATION FOR
CHEMISTRY ONLINE TUITION

- UK Contact: 02081445350
- International Phone/WhatsApp: 00442081445350
- Website: www.chemistryonlinetuition.com
- Email: asherrana@chemistryonlinetuition.com
- Address: 210-Old Brompton Road, London SW5 OBS, UK