Mark schemes

1

(a) Selects correct titres

If 3 or more titres used them MAX 1 for conseq M3

1

$$\text{mean titre} = \frac{9.75 + 9.65}{2}$$

$= 9.7(0)\ cm^3$

Calculates mean

1

mol HCL $= 0.102 \times 9.70/1000 = 9.89 \times 10^{-4}$

(allow 9.9 × 10-4 for M3 but check not via 4 titres in which case only 1 mark)

Calculates mol (working or result gains credit)

9.92×10^{-4} scores 1 if all 4 titres used

9.83×10^{-4} scores 1 if titres 1,2, and 3 used

1

(b) mol $MHCO_3$ = ANS 3.1 × 10 (= 9.89×10^{-3})

Use ecf if wrong mean calculated above

1

$$Mr = \frac{1464/1000}{M1}$$

1

Mr = 148 (3sf)

Allow ecf following wrong mass conversion

1

(c) Suggestion: Use a larger mass of solid OR use a more concentrated solution of $MHCO_3$ OR less concentrated / more dilute solution of HCl OR more $MHCO_3$

1

Cannot score justification mark unless suggestion correct, but suggestion could be after justification

Justification: So a larger titre/reading will be needed OR larger volume of HCl

Assume reference to the solution means the $MHCO_3$

1

(d) This question is marked using levels of response.

Level 3
Must use volumetric flask to access level 3
Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.

All stages are covered and the description of each stage is complete

6 marks

All stages are covered but up to 2 omissions/errors from different stages. If 2 omissions/errors from same stage only level 2 possible

5 marks

Level 2
Answer is mainly coherent and shows progression from stage 1 to stage 3

All stages are covered but 3 omissions/errors

4 marks

All stages are attempted

3 marks

Level 1
Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

2 stages attempted

2 marks

1 stage attempted

1 mark

Level 0
Insufficient correct chemistry to gain a mark.

0 marks

Indicative Chemistry content

Stage 1*: transfers known mass of solid*

a) Weigh the sample bottle containing the solid on a (2 dp) balance

b) Transfer to beaker and reweigh sample bottle*

c) Record the difference in mass

Or

d) Place beaker on balance and tare*

e) Transfer solid into beaker

f) Record mass

Or

g) Known mass provided

*h) Transfers (known) mass into beaker**

i) Wash all remaining solid from sample bottle into beaker

Allow use of weighing boat

**Allow other suitable glassware including volumetric flask*

***Stage 2**: Dissolves in water*

a) Add distilled / deionised water

b) Stir (with a glass rod) or swirl

c) Until all solid has dissolved

***Stage 3**: Transfer, washing and agitation*

a) Transfer to volumetric / graduated flask. Allow if a clear description/diagram given eg long necked flask with 250 cm^3 mark

b) With washings

c) Make up to 250 cm^3 / mark with water

d) Shakes/inverts/mixes

6

[14]

2 (a) n = PV/RT

If PV=nRT rearranged incorrectly then M3 only

1

$$\frac{102\,000 \times (1.00 \times 10^{-3})}{8.31 \times 300} = n = (4.091456077 \times 10^{-2})$$

1

Mass = M2 × 17 = 0.696 (g) (3 sig figs only)

Allow 0.695 or 0.697

1

(b) If pV = nRT

Total volume = $\frac{nRT}{P}$

Incorrect unit conversion loses M1 only; can get M2/M3 if possible volume obtained

$= \frac{n \times 8.31 \times 295}{75\,000}$

= 1.34×10^{-3} m^3

Inserts correct numbers (inc pressure in Pa)

1

Volume of Q in m^3 = 1.00×10^{-3}

Volume of bulb P = $1.34 \times 10^{-3} - 1.00 \times 10^{-3}$

Volume of bulb P = 3.42×10^{-4} m^3

No subtraction M1 only

1

= 342 cm^3 (Allow 310 − 342 cm^3)

Alternative method also worth full credit

(note if mol in M2 of 05.1 rounded to 0.04 this could lead to a final answer of 3.1 × 10^{-4} m^3 so allow range 310 − 342 cm^3

1

[6]

3 Identifies precipitate as being $BaSO_4$

1

Moles of Barium sulfate = mass/Mr
(= 0.764 / 233.4)
= 0.003273 moles

Allow conseq if Mr $BaSO_4$ or $BaCl_2$ incorrect

1

Mass of Barium chloride = 208.3 × 0.003273 = 0.6818 g

1

Percentage of Magnesium chloride = $\frac{1.056 - 0.6818}{1.056} \times 100$

Do NOT penalise incorrect precision here

Allow range 33.7-35.5% (rounding errors penalised elsewhere in paper)

1

[4]

4 B

[1]

5 C

[1]

6 C

[1]

7 C

[1]

8 D

[1]

9 B

[1]

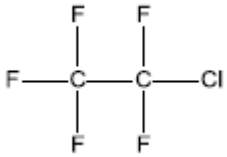
10 (a) M1 $\bullet Cl + O_3 \longrightarrow \bullet ClO + O_2$

1

M2 $\bullet ClO + O_3 \longrightarrow \bullet Cl + 2O_2$

1

M1 and M2 could be in either order
Credit the dot anywhere on the radical
Penalise absence of dot once only
Individual multiples acceptable but both need to be doubled if two marks are to be awarded
Ignore state symbols

(b) 

Must be displayed formula

1

(c) Does not contain Cl or does not release Cl (atoms/radicals)
or no C-Cl bonds
or C-F bond(s) strong / does not break / no F (atom/radicals) released

1

(d) M1 $CHF_2CH_3 + \bullet F \longrightarrow \bullet CF_2CH_3 + HF$

1

M2 $\bullet CF_2CH_3 + F_2 \longrightarrow CF_3CH_3 + \bullet F$

1

M1 and M2 could be in either order
Credit the dot anywhere on the radical
Penalise absence of dot once only

(e) M1 moles CF_3CH_3 = 1410/84(.0) (=16.8, 16.79 mol)

1

M2 molecules = M1 × 6.022 × 10^{23} = 1.01 × 10^{25} (3sf only)

1

Correct answer scores both marks

Allow M2 for M1 × Avogadro with answer to 3 sf (but must have attempted to calculate moles for M1)

Ignore incorrect units

(f) (bonds) vibrate/stretch/bend OR (as bonds) are polar

NOT polar molecules; 'they' = bonds

1

[9]

11 (a) **Method 1**

Allow working throughout to 2sf

M1 Moles of Mg = 0.396/24.3 = 0.0163

1

M2 Moles of CH_3COOH = 0.600 × 30.0/1000 = 0.018

1

M3 Mark for showing Mg is in excess: either
0.018 mol of CH_3COOH reacts with 0.009 mol of Mg OR
0.0163 mol of Mg reacts with 0.0326 mol of CH_3COOH OR
0.0073 mol of Mg is in excess

1

If candidate gets 16.3 mol (as not converted mg to g) in method 1 or 3 then can only score 1 mark maximum (M2)

Accept other valid calculations that show the Mg is in excess

Method 2

M1 Moles of CH_3COOH = 0.600 × 30.0/1000 = 0.018

M2 Moles of Mg that would react with this = 0.009

M3 Mass of Mg needed = 24.3 × 0.009 = 0.219 g which is less than 0.396 g OR
Moles of Mg = 0.0163 which is more than 0.009 required

Method 3

M1 Moles of Mg = 0.396/24.3 = 0.0163

M2 Moles of CH_3COOH that would react with this = 0.0326

M3 Volume of CH_3COOH needed = 0.0326 / 0.60 = 0.0543 dm^3 (54.3 cm^3) which is more than 0.030 dm^3 (30 cm^3)

(b) M1 Line starts at origin and is steeper

1

M2 (moles $CH_3COOH = 0.800 \times 20/1000 = 0.016$) line levels out on 8^{th} line up (line below the original 9^{th} line)

M2 for line on 8^{th} line on grid (original on 9^{th} line) – allow some leniency so long as clear it ends at (or very close to) the 8^{th} line; and line does not significantly wobble

1

[5]

12 D

[1]

13 B

[1]

14 D

[1]

15 C

[1]

16 (a) (i) $H_2O + CO_2$ (as products in any equation)

Allow $H_2O + H_2CO_3$

1

$Cu_2(OH)_2CO_3 + 4HCl \rightarrow 2CuCl_2 + 3H_2O + CO_2$

Allow multiples

Ignore states

1

(ii) Bubbles or fizzing or effervescence
Or solid disappears
Or blue(-green) solution

Do not allow dissolves

Ignore CO_2 gas or gas evolved

1

(b) (i) Simplest (whole-number) ratio of atoms of each element in a compound

Allow atoms of Cu, H & O in this compound

1

(ii) Mass of copper = 2.765

Dividing masses by A_r

1

Cu	C	H	O
$\frac{2.765}{63.5}(=0.0435)$	$\frac{0.348}{12.0}(=0.029)$	$\frac{0.029}{1.0}(=0.029)$	$\frac{1.858}{16.0}(=0.116)$

1

Correct whole number ratio of integers

or

Cu:C:H:O

3:2:2:8

or

Correct empirical formula $Cu_3C_2H_2O_8$

Any order

Ignore $Cu_3(OH)_2(CO_3)_2$

1

[7]

17 (a) Correct conversion of temperature and pressure (773 and 101×10^3)

Correct answer with or without working scores 4 marks

1

No moles P = (220 / 4 × 31.0) = 1.77

Max 2 (M1 and M3) if 31.0 used

(=0.451 m^3 or if 220/31 rounded to 2 sf ie 7.1 then 0.452)

1

V = nRT/P (correct rearrangement **or** insert of values V = 1.77 × 8.31 × 773/101 × 10^3 =0.1128 m^3)

Max 2 (M1 and M3) if 284 (P_4O_{10}) used then 0.0493

1

V = 0.113 (m^3)

Must be 3 sig figs

1

(b) No moles $H_3PO_4 = 3 \times 10^3$ (dm^3) × 5 = 15,000 (mols)

Correct answer with or without working scores 3 marks

If M1 incorrect then can only score M2

1

No moles phosphorus(V) oxide = $\frac{15000}{4}$ (= 3,750 mols)

$M2 = \frac{M1}{4}$ (process)

If M2 incorrect can only score M1

1

1.1×10^6 or1.07×10^6 or 1.065×10^6 (g)
or 1,100 or 1,070 or 1065 kg
or 1.1 or 1.07 or 1.065 tonne

= (3.75 × 10^3 × 284.0)

Min 2 sig fig

1

(c) No moles $Ca_3(PO_4)_2$ (= 3.50kg =) $\frac{3500\ g}{310(.3)} = 11.28$

Correct answer with or without working scores 4 marks

If M1 incorrect can only score M2 and M3

1

Theoretical No. moles $H_3PO_4 = 11.28 \times 2 = 22.56$

If M2 incorrect can only score M1 and M3

1

Theoretical mass $H_3PO_4 = 22.56 \times 98(.0) = 2211$

If M3 incorrect can only score M1and M2

1

or Actual No. moles H_3PO_4 produced = $\frac{1090}{98} = 11.12$

49 – 49(.312) (%)

$(\%\ \text{yield (moles)} = (\frac{11/.12}{22.56} \times 100)$

or $(\%\ \text{yield (mass)} = (\frac{1090}{2211} \times 100)$

1

(d) Method 1 / (a) & (b) because only one product / no other products formed / atom economy = 100% (even though two steps)

Allow calculations

Do not allow if P_2O_5 is formed

Allow converse explanation

1

[12]

18 (a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Allow correct numbers that are not superscripted

1

(b) $Ca(s) + 2H_2O(l) \longrightarrow Ca^{2+}(aq) + 2OH^-(aq) + H_2(g)$

State symbols essential

1

(c) Oxidising agent

1

(d) $Ca(g) \longrightarrow Ca^+(g) + e^-$

State symbols essential

Allow 'e' without the negative sign

1

(e) Decrease

If answer to 'trend' is not 'decrease', then chemical error = 0 / 3

1

Ions get bigger / more (energy) shells

Allow atoms instead of ions

1

Weaker attraction of ion to lost electron

1

[7]

19 (a) $C(s) + 2F_2(g) \longrightarrow CF_4(g)$

State symbols essential

1

(b) Around carbon there are 4 bonding pairs of electrons (and no lone pairs)

1

Therefore, these repel equally and spread as far apart as possible

1

(c) $\Delta H = \Sigma\ \Delta_f H$ products $- \Sigma\ \Delta_f H$ reactants or a correct cycle

1

Hence = $(2 \times -680) + (6 \times -269) - (x) = -2889$

1

$x = 2889 - 1360 - 1614 = -85$ (kJ mol^{-1})

1

Score 1 mark only for +85 (kJ mol^{-1})

(d) Bonds broken = 4(C–H) + 4(F–F) = 4 × 412 + 4 × F–F

Bonds formed = 4(C–F) + 4(H–F) = 4 × 484 + 4 × 562

Both required

1

$-1904 = [4 \times 412 + 4(F–F)] - [4 \times 484 + 4 \times 562]$

$4(F–F) = -1904 - 4 \times 412 + [4 \times 484 + 4 \times 562] = 632$

1

F–F = 632 / 4 = 158 (kJ mol^{-1})

1

The student is correct because the F–F bond energy is much less than the C–H or other covalent bonds, therefore the F–F bond is weak / easily broken

Relevant comment comparing to other bonds

(Low activation energy needed to break the F–F bond)

1

[10]

20 (a) Stage 1: appreciation that the acid must be in excess and calculation of amount of solid that permits this

Statement that there must be an excess of acid

1

Moles of acid = 50.0 × 0.200 / 1000 = 1.00 × 10^{-2} mol

1

2 mol of acid react with 1 mol of calcium hydroxide therefore moles of solid weighed out must be less than half the moles of acid = 0.5 × 1.00 × 10^{-2} = 5.00 × 10^{-3} mol

1

Mass of solid must be < 5.00 × 10^{-3} × 74.1 = < 0.371 g

1

Stage 2: Experimental method

Measure out 50 cm^3 of acid using a pipette and add the weighed amount of solid in a conical flask

1

Titrate against 0.100 (or 0.200) mol dm^{-3} NaOH added from a burette and record the volume (v) when an added indicator changes colour

1

Stage 3: How to calculate M_r from the experimental data

Moles of calcium hydroxide = 5.00 × 10^{-3} – (v/2 × conc NaOH) / 1000 = z mol

1

M_r = mass of solid / *z*

1

Extended response

Maximum of 7 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

(b) Moles of calcium chloride = 3.56 / 111.1 = 3.204 × 10^{-2}

1

Moles of calcium sulfate = 3.204 × 10^{-2} × 83.4 / 100 = 2.672 × 10^{-2}

1

Mass of calcium sulfate = $2.672 \times 10^{-2} \times 136.2 = 3.6398 = 3.64$ (g)

Answer must be to 3 significant figures

1

[11]