



# Coimisiún na Scrúduithe Stáit State Examinations Commission

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**Ceimic**

Scrúduithe Ardteistiméireachta, 2007  
**Ardleibhéal**

Marking Scheme  
**Chemistry**

Leaving Certificate Examination, 2007  
**Higher Level**



**Coimisiún na Scrúduithe Stáit**  
**State Examinations Commission**

*Leaving Certificate Examinations 2007*

*Chemistry – Higher Level*

*Marking Scheme*

# Introduction

**In considering the marking scheme the following should be noted.**

1. In many cases only key phrases are given which contain the information and ideas that must appear in the candidate's answer in order to merit the assigned marks.
2. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.
3. The detail required in any answer is determined by the context and the manner in which the question is asked, and by the number of marks assigned to the answer in the examination paper and, in any instance, therefore, may vary from year to year.
4. The bold text indicates the essential points required in the candidate's answer. A double solidus (//) separates points for which separate marks are allocated in a part of the question. Words, expressions or statements separated by a solidus (/) are alternatives which are equally acceptable for a particular point. A word or phrase in bold, given in brackets, is an acceptable alternative to the preceding word or phrase. Note, however, that words, expressions or phrases must be correctly used in context and not contradicted, and where there is evidence of incorrect use or contradiction, the marks may not be awarded.
5. In general, names and formulas of elements and compounds are equally acceptable except in cases where either the name or the formula is specifically asked for in the question. However, in some cases where the name is asked for, the formula may be accepted as an alternative.
6. Partial marks for incorrectly completed, or uncompleted, calculations may only be awarded where the significance of the numbers used is clearly indicated in the candidate's work. There is a deduction of one mark for each arithmetical slip made by a candidate in a calculation.

## Outline Marking Scheme

**Eight questions** to be answered in all. These *must* include at **least two** questions from **Section A**.

### Section A

- (a) Primary, Standard 5 + 3; (b) Describe 5 x 3; (c) What 3; (d) Colours 4 x 3; (e) Molarity 6, Grams per litre 6.
- (a) State 2 x 4; (b) Describe 2 x 3, Explain 3; (c) Purpose 2 x 3; (d) Show 4 x 3; (e) Describe 6; (f) Describe 3, Write 2 x 3.
- (a) What 4, State 4; (b) Which 3; (c) Explain 6; (d) List 3 x 3; (e) What 3; (f) Calculate 6, Taking 6, Hence 6; (g) Name 3.

### Section B

- (a) Define 2 x 3; (b) What 6; (c) Distinguish 2 x 3; (d) What 6; (e) Intake 6; (f) Name 2 x 3; (g) Used 2 x 3; (h) Calculate 6; (i) Explain 6; (j) What 2 x 3; (k) **A** 6; (k) **B** 6.
- (a) Define 5, Write 3, Show 3, State (i) 3, (ii) 3; (b) Use 6, Write 3, Show 6, Would 3, Justify 3; (c) Account 6, Would 3, Explain 3.
- (a) Which 5, Give 3 x 3, Which 3, Justify 6, Write 2 x 3; (b) How 3, Explain 3 x 3, Give 3; (c) What 3, Economic 3.
- (a) (i) 4, (ii) 4, Identify 2 x 3, Distinguish 3, 3; (b) Calculate 9, What 6; (c) Describe 3 x 3; (d) Explain 6.
- (a) Name (i) 4, (ii) 4; (b) What 2 x 3; (c) Reagent 3, Catalyst 3; (d) Draw 2 x 3, Indicate 3, List 3 x 3; (e) How 3 x 3, (f) How 3.
- (a) Define 4, Why 4; (b) Plot 3, 6, 3, Use (i) 6, (ii) 3; (c) Describe 3, Explain 3; (d) (i) Mark 6, (ii) Dust 3 x 3.
- (a) (i) Write 7, (ii) Calculate 12, (iii) What 3, Explain 3.  
(b) (i) State 4, 3, (ii) What 9, What 6, (iii) Give 3.  
(c) (i) How 4, (ii) Assign 4 x 3, Balance 6, (iii) Why 3.
- (a) (i) Describe 4 + 3, (ii) State 3, 3, Explain 3, 3, (iii) Copy 6.  
(b) (i) State 4 + 3, (ii) Name 2 x 3, (iii) Account 6, (iv) Name 3, (v) Give 3.  
(c) **A** (i) State 4, (ii) What 6, (iii) Name 2 x 3, (iv) What 3 x 3.  
(c) **B** Name 3 + 2 + 2, Explain (i) 2 x 3, (ii) 2 x 3, (iii) 2 x 3.

## SECTION A

At least *two* questions must be answered from this section.

### QUESTION 1

(a) PRIMARY: **pure / stable / anhydrous (not hydrated) / no water loss (no efflorescence) / not deliquescent / not hygroscopic / does not sublime / high molecular (molar) mass ( $M_r$ ) //**

from which solutions of **known concentration (molarity)** can be made /  
**no need to standardise by titration / water soluble** (5 + 3)

(b) DESCRIBE: **rinse** from clock glass **into beaker** containing deionised water //  
**stir // dissolve //**  
**pour (add) through funnel** into volumetric flask //  
**add rinsings** of beaker //  
**add deionised water until bottom of meniscus on (level with) mark /**  
**read at eye level //**  
stopper and **invert\*** several times ANY FIVE: (5 × 3)  
[\* Do not allow “shake” for “invert”]

(c) WHAT: source of **iodide ( $I^-$ )** ions (potassium **iodide**, KI) (3)

(d) COLOURS: **red / brown / reddish brown / golden-brown / yellow-brown** (3)  
**orange / yellow / light yellow / straw coloured** (3)  
**blue-black / blue** (3)  
**colourless** [Do not accept ‘clear’] (3)  
Give marks if order is correct even if one or more omitted. Can also be marked divided into first two and last two.

(e) MOLARITY: **0.125 mol l<sup>-1</sup>** (6)

$\frac{20 \times M}{2} = \frac{25 \times 0.05}{1} \quad (3) \quad M = 0.125 \quad (3)$
--

GRAMS l<sup>-1</sup>: **31 g l<sup>-1</sup>** (6)

$0.125 \times 248^* \quad (3) \quad = \quad 31 \text{ g l}^{-1} \quad (3)$ <p><i>*addition must be shown for error to be treated as slip.</i></p>
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## QUESTION 2

- (a) STATE: **add in small quantities (add dropwise)** [Allow “add slowly”.] //  
**shake (stir) after each addition / wait till reaction ceases (subsides) //**  
**cool reaction vessel** ANY TWO: (2 × 4)
- (b) DESCRIBE: **orange** (3)  
**to green** (3)
- EXPLAIN: **dichromate (Cr<sup>6+</sup>, Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>, Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>) reduced to chromium(III) (Cr<sup>3+</sup>)** (3)  
[Accept use of oxidation numbers.]
- (c) PURPOSE: **to speed up reaction (oxidation) //**  
**to ensure complete oxidation (reaction) / to ensure oxidation does not stop at**  
**ethanal (CH<sub>3</sub>CHO) / but goes on to ethanoic acid (CH<sub>3</sub>COOH) //**  
**to heat without loss of vapour (product)** ANY TWO: (2 × 3)
- (d) SHOW: mass of ethanol = 8.0 × 0.80 = **6.4 g** (3)  
moles of ethanol = 6.4 ÷ 46\* = **0.139 (0.14) mol** (3)  
moles dichromate = 29.8 ÷ 298\* = **0.1 mol** (3)  
**0.139 ethanol ( × <sup>2</sup>/<sub>3</sub>) ≡ 0.09 mol dichromate /**  
**0.1 mol dichromate ( × <sup>3</sup>/<sub>2</sub>) ≡ 0.15 mol ethanol** (3)  
[\*addition must be shown for error to be treated as slip.]
- (e) DESCRIBE: isolated by **distillation (or distillation diagram)** (6)
- (f) DESCRIBE: **effervescence / fizzing / bubbling / gas (CO<sub>2</sub>) given off** (3)
- WRITE: **Na<sub>2</sub>CO<sub>3</sub> + 2CH<sub>3</sub>COOH → 2CH<sub>3</sub>COONa + H<sub>2</sub>O + CO<sub>2</sub> /**  
**Na<sub>2</sub>CO<sub>3</sub> + 2CH<sub>3</sub>COOH → 2CH<sub>3</sub>COONa + H<sub>2</sub>CO<sub>3</sub>**  
FORMULAS (3) BALANCING (3)

### QUESTION 3

(a) WHAT: **corrosive (corrosiveness, corrosion)** (4)

STATE: **do not allow contact with skin (eyes) /  
protective clothing (gloves, lab. coat) / eye protection (glasses, screen)** (4)

(b) WHICH: **burette** (3)

(c) EXPLAIN: **get average (mean) temperatures of the two solutions /  
wait until both solutions at same (room) temperature /  
using plot of temp. v time for both solutions** (6)

(d) LIST: **thermometer to 0.2 °C or better (temperature sensor, “sensitive”, “accurate”) //  
add quickly // add without splashing // replace cover quickly (immediately) //  
stir constantly // after addition plot temperature at intervals and get highest  
temperature by extrapolating back to time of mixing // prevent heat loss (use  
of suitable insulation)** ANY THREE: (3 × 3)  
[Do not accept “digital thermometer”.]

(e) WHAT: polystyrene a good **insulator** / **glass & metal poorer insulators** (3)  
[Accept “prevents heat loss” or “not a conductor” for “insulator”]

(f) CALCULATE: **0.05 mol** (6)

$$\frac{50}{1000} \quad (3) \quad \times 1 = 0.05 \quad (3)$$

TAKING: **2814 J / 2.814 kJ** (6)

$$420 \times 6.7 \quad (3) \quad = 2814 \quad (3)$$

[If 4200 is used incorrectly minimum of 3 marks to be lost]

HENCE: **– 56280 J mol<sup>-1</sup> / – 56.28 (– 56.3) kJ mol<sup>-1</sup>** [minus is in bold] (6)

$$\frac{2814}{0.05} \quad (3) \quad - 56280 \quad (3)$$

(g) NAME: **bomb calorimeter** (3)

## SECTION B

### QUESTION 4

**Eight items to be answered. Six marks to be allocated to each item and one additional mark to be added to each of the first two items for which the highest marks are awarded.**

- [If only two are attempted and neither is awarded marks: (2 x 1)]
- (a) DEFINE: **half the internuclear distance / half the distance between the centres** (3)  
**in a single homonuclear bond / of singly-bonded atoms of the same element** (3)  
 [For a diagram to be awarded the marks, all the information must be clearly shown.]

- (b) WHAT: **raise octane number / prevent auto-ignition (pre-ignition, knocking, pinking) / cleaner emissions / less pollution / less carbon monoxide (CO) produced** (6)  
 [allow 3 marks for “as additives”]

- (c) DISTING: *sigma*: **head-on (end-on) overlap of orbitals** (3)  
*pi*: **lateral (sideways) overlap orbitals** (3)  
 [Marks can be got from clearly labelled diagrams]  
 [allow max. of 3 marks if either “orbitals” not stated above  
 or if “orbitals” are not labelled in diagram.]


- (d) WHAT: **reactants & catalyst in different phases / boundary between reactants & catalyst** (6)  
 [Allow (3) if “states” used for “phases”; no marks for an example]

- (e) INTAKE:  **$1.5 \times 10^{20}$**  (6)  

$$\boxed{0.014 \div 56 = 0.00025 \quad (3) \quad \times 6 \times 10^{23} = 1.5 \times 10^{20} \quad (3) \quad \times 2 \quad (-3)}$$

- (f) NAME: **iron(II) sulfate / ferrous sulphate /  $\text{FeSO}_4$**  [Accept ammonium iron(II) sulfate] //  
**concentrated sulphuric acid /  $\text{H}_2\text{SO}_4$**  (2 x 3)

- (g) USED: **name // structure** (2 x 3)

ethanoic (acetic) acid //  $\text{CH}_3\text{COOH}$   
 propanoic (propionic) acid //  $\text{CH}_3\text{CH}_2\text{COOH}$  ( $\text{C}_2\text{H}_5\text{COOH}$ )  
 benzenecarboxylic (benzoic) acid //  $\text{C}_6\text{H}_5\text{COOH}$    $\text{COOH}$ )  
 methanoic acid //  $\text{HCOOH}$   
 sorbic acid\* //  $\text{CH}_3(\text{CH})_4\text{COOH}$  [\* 2,4-hexadienoic acid]

- (h) CALC: **4.3** (6)  

$$\boxed{\frac{21.5}{500} \quad (3) \quad \times 100 \quad = \quad 4.3 \quad (3)}$$

- (i) EXPL: **all the carbon-to-carbon bonds in benzene are identical (same length) / resonance (delocalised) structure / bonds intermediate between single and double / six valence (bonding) electrons belong to whole molecule** (6)  
 [Accept: “double bonds moving” or “double bonds not fixed”]  
 [Allow (3) for: intermediate **between the two** (shown or stated) Kekule **structures**]

- (j) WHAT: **absorbance is // directly proportional to (varies directly with) concentration** of substance (2 x 3)

- (k) A: **hydrochlorofluorocarbons (HCFCs) / hydrofluorocarbons (HFCs) / perfluorocarbons (PFCs)** (6)  
 B: **Sir Humphry Davy** (6)



## QUESTION 5

(a) DEFINE: **discrete (fixed, restricted, definite, specific) energy of electron / energy of electron in orbit / orbit (shell) which electrons of equal energy can occupy** (5)

WRITE:  **$1s^2 2s^2 2p^6 3s^2 3p^4$  /  $[\text{Ne}] 3s^2 3p^4$**  [Accept if written with subscripts] (3)  
 [Do not accept “ $3p_x^2 3p_y^2$ ” for “ $3p^4$ ”]

SHOW:  **$3p_x^2 3p_y^1 3p_z^1$  /  $\boxed{\uparrow\downarrow} \boxed{\uparrow} \boxed{\uparrow}$**   / [can be drawn separately] (3)

[Note:  **$1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^1 3p_z^1$**  (6)]

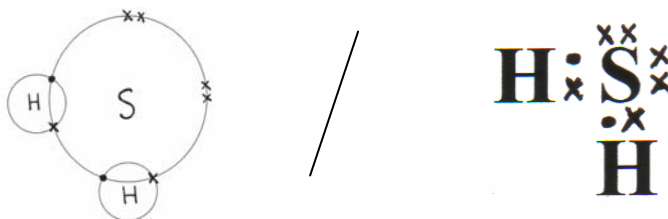
[The electron pair can be shown in the  $p_x$ , the  $p_y$  or the  $p_z$  orbital with the other two orbitals having one electron each]

STATE: (i) **3** (3)  
 (ii) **9** (3)

(b) USE: **weakly polar // almost non-polar // covalent bond** (6)  
 [Allow 3 marks for “*polar covalent*”]

WRITE:  **$\text{H}_2\text{S}$**  [Accept  $\text{SH}_2$ ] (3)

SHOW:



(6)  
 [Accept all dots or all crosses, also  $\bullet - \times$  or  $\bullet - \bullet$  for bonds. Correct shape not required.]

WOULD: **non-linear** (3)

JUSTIFY: **there are non-bonding (lone) pair(s) /** [Allow 1.p. for lone pair.]  
**four (> two) electron pairs in valence (outer) shell of central (S) atom** (3)  
 [Linked answers]

(c) ACC: **hydrogen bonds in water // weak dipole-dipole\* forces in  $\text{H}_2\text{S}$  / London dispersion forces in  $\text{H}_2\text{S}$  / weaker intermolecular forces in  $\text{H}_2\text{S}$**  [\*Accept Van der Waals' forces] (6)  
 [Accept “big electroneg. diff. between O and H but small between S and H for (3)"]

WOULD: only **slightly (sparingly, weakly) soluble / no** (3)

EXPL: **does not form hydrogen bonds with water /  $\text{H}_2\text{S}$  weakly (non-) polar** (3)  
 [Linked answers]

## QUESTION 6

(a) WHICH: **light gasoline (petrol)** [Accept “petroleum”] (5)  
 [Allow “second highest fraction” or “from C<sub>5</sub> to C<sub>10</sub>(C<sub>11</sub>)”]

GIVE: **pentane // 2-methylbutane // 2,2-dimethylpropane** (3 x 3)  
 [If the names are not given in the same order as the formulas, there must be some way of identifying which formula the candidate is naming. Numbers are not required as the structures are unambiguous but no marks should be awarded if incorrect numbers are used]

WHICH: **pentane / the first one / the one on the left / pentane structure** (3)

JUSTIFY: **pentane is a straight (unbranched) chain molecule** (6)  
 [“longest chain” or “not highly branched” are not acceptable.]

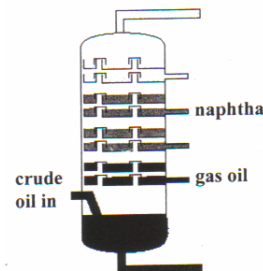
WRITE: **C<sub>5</sub>H<sub>12</sub> + 8O<sub>2</sub> → 5CO<sub>2</sub> + 6H<sub>2</sub>O** FORMULAS: (3) BALANCING: (3)

(b) HOW: **naphtha (they) have shorter (smaller, less carbon atoms, smaller mass, lighter) chains / gas oil have longer (bigger, more carbon atoms, bigger mass, heavier) chains** (3)

EXPL: **diagram with one correct label** (3)  
 [layers *or* outlets must be shown; outlets may be shown by tubes (pipes), holes, gaps, lines, arrows (→)]

**heat (boil) / pass vapour up tower (column) / temperature gradient shown** (3)

**naphtha condenses (comes off) higher up / gas oil comes off lower down** (3)



GIVE: **road surfacing (tarring) / roofing / waterproofing** (3)

(c) WHAT: **splitting (breaking) of long chain molecules** by heat and catalyst(s) (3)  
 [Accept “hydrocarbons” for “molecules”]

ECON: **gives useful products (more demand for products) / products needed for petrol / products used as feedstock for chemical industry (source of alkenes) / gives higher octane numbers** (3)

## QUESTION 7

(a) (i) *acid*: **proton (hydrogen ion, H<sup>+</sup>) donor** (4)

(ii) *conjugate pair*: **acid & base that differ by a proton (hydrogen ion, H<sup>+</sup>)** (4)

IDENTIFY: **HNO<sub>2</sub> & NO<sub>2</sub><sup>-</sup> // H<sub>2</sub>O & H<sub>3</sub>O<sup>+</sup>** (2 × 3)

DISTING: *strong*: **good proton donor / completely (high) dissoc.** into ions in dil. aq. soln. (3)

*weak*: **poor proton donor / slightly (low) dissoc.** into ions in dil. aq. soln. (3)  
[Accept “does not readily dissoc.” but not “does not completely (fully) dissoc.”]

(b) CALC: **pH = 2.15** [or answers that give 2.15 when corrected to two decimal places.] (9)

$\text{pH} = -\log \sqrt{K_a \times M}$ (3)	$K_a = \frac{[\text{H}^+][\text{NO}_2^-]}{[\text{HNO}_2]} = \frac{[\text{H}^+]^2}{0.1} = 5 \times 10^{-4}$
$= -\log \sqrt{5 \times 10^{-4} \times 0.1}$ (3)	$[\text{H}^+]^2 = 5 \times 10^{-5}$ (3)
$= 2.15$ (3)	$[\text{H}^+] = 0.007$ (3)
	$\text{pH} = 2.15$ (3)

WHAT: **1** (6)

$\text{pH} = -\log [\text{H}^+] = -\log [0.1]$ (3)
$= 1$ (3)

(c) DESCR: **enrichment with nutrients (fertilisers / nitrates / phosphates) //**

**due to run off from land (erosion from land) / due to pollution / dispersion in water / absorption by plants //**

**rapid growth of plants (algae) on surface / algal blooms formed //**

**light blocked from (photosynthesis reduced in) plants below surface / decay by micro-organisms (bacteria) of surface plants (algae, algal blooms) / increase in micro-organisms (bacteria) / increased activity by aerobic micro-organisms (bacteria) //**

**dissolved oxygen depleted (lowered, used up) / oxygen level falls / deoxygenation**

ANY THREE: (3 × 3)

(d) EXPL: **precipitation / adsorption / absorption / ion exchange (deionising) / complexation** (6)

[Allow (3) for “flocculation”. Give no marks for “distillation”]

### QUESTION 8

- (a) NAME: (i) **alkenes (olefins)** (4)  
 (ii) **aldehydes (alkanals)** (4)

- (b) WHAT: **loss of (removal of) small molecule (water, hydrogen chloride, H<sub>2</sub>O, HCl)** (3)  
 [Accept “dehydration”]

**change to (formation of) unsaturated compound (double bond, planar carbon / planar geometry)** (3)

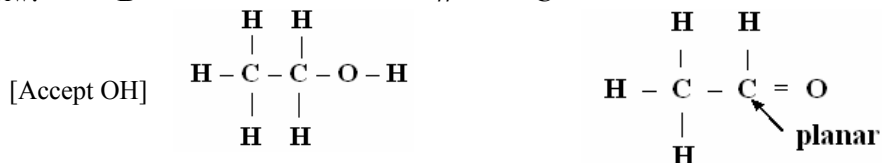
[Note: equation not sufficient on its own; the features must be stated.]

- (c) REAGENT: **hydrogen** [Accept: ‘hydrogenation’] (3)  
 [Reagent-catalyst order not required]

CATALYST: **nickel (Ni) / palladium (Pd) / platinum (Pt)** (3)

[ Accept: **lithium aluminium hydride (LiAlH<sub>4</sub>, lithium tetrahydroaluminate) / sodium borohydride (NaBH<sub>4</sub>, sodium tetrahydroborate)** for 6 marks]

- (d) DRAW: **B** // **C** (2 x 3)



INDICATE: **correct indication of planar carbon atom** (3)

LIST: *bonds broken in B:* **C – H // O – H** (2 x 3)

*bond made in C:* **C = O** [Accept “carbon (C) to oxygen (O) bond”] (3)  
 [cancelling applies]

- (e) HOW: **heat / warm / boil // with specified reagent // observation** (3 x 3)

<u>reagent</u>	<u>observation</u>
Fehling’s solution	red (orange, etc.) ppt.
Tollens’ reagent (ammoniacal silver nitrate, ammoniacal silver oxide, ammoniacal silver ions)	silver
2,4-dinitrophenylhydrazine (6 marks)	orange (red, yellow) ppt.

[“silver mirror test” on its own gets (3)]

- (f) HOW: **ingestion (drink, food, medicine)** (3)

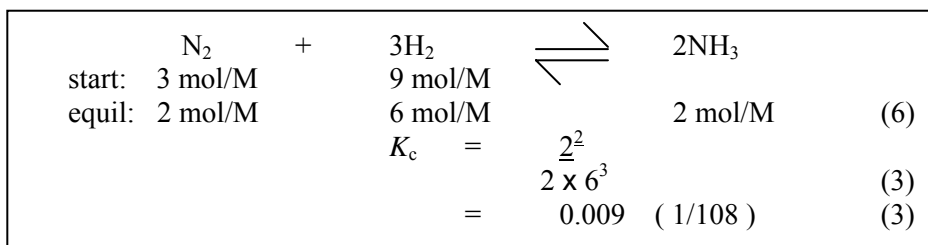
## QUESTION 9

- (a) DEFINE: **change\* in concentration per unit time / rate of change\* of concentration / change\* in concentration** [\* “increase” or “decrease” not acceptable for “change”]  
**time** (4)  
[Accept ‘mass’ or ‘amount’, but not ‘volume’ or ‘quantity’, for ‘concentration’]
- WHY: **concentration(s) decrease [reactant(s) used up]** (4)
- (b) PLOT: **labelled and scaled axes** [Accept ‘time’ or ‘minutes’; ‘mass’ or ‘grams’] (3)  
**all points plotted correctly** (6)  
[Allow (3) if six points are correctly plotted; assume (0, 0) is plotted correctly]  
**curve drawn** [has to be drawn to (0, 0)] (3)  
Note: award (6) for *plotted correctly* only if graph paper is used, otherwise 0.  
[Allow if the axes are reversed.]
- USE: (i) **0.20 – 0.26 g min<sup>-1</sup>** (6)  
[allow 3 marks for good tangent *or* 3 marks for calculation based on data points from candidate’s tangent]  
(ii) **0.004 – 0.006 mol min<sup>-1</sup>** (3)
- (c) DESCRIBE: **slower rate** (3)
- EXPLAIN: **acid less concentrated / rate decreases with concentration / fewer collisions at lower concentration** (3)
- (d) (i) MARK: **see candidate’s graph\*** [steeper at start; levels off sooner; reaches same height] (6)  
[Allow (3) if description is fully correct but not shown on the graph]  
[Allow (3) if two of the three conditions above are shown on the graph]  
\* not necessarily on graph paper.
- (ii) DUST: **combustible dust particles // dryness // above certain concentration // source of ignition (light, spark, flame, static electricity) // oxygen (air, atmosphere)\* // enclosed space** ANY THREE: (3 x 3)  
[\*Can be picked out of description if clear that it is a condition.]  
[Allow “build up” or “enough of dust” or “spread out” for “certain concentration”.]  
[Allow “lack of ventilation” for “enclosed space”.] [Do not accept “heat” for “ignition source”]

### QUESTION 10

(a) (i) WRITE:  $\frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$  [Square brackets essential] (7)

(ii) CALC: **0.009 (1/108) M<sup>-2</sup>** (12)  
[or answers that give 0.009 correct to one significant figure]



(iii) WHAT: it would **increase** the yield of ammonia (3)  
[The increase in yield of ammonia must be mentioned; no marks for “reaction shifts forward” or “reaction shifts to the right”.]

EXPL: **reaction shifts in direction (to side) of fewer molecules (moles) (smaller volume)** to decrease the pressure (3)

(b) (i) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (4)

**under same conditions\*** of temperature and pressure (3)

[\* Do not accept “under all conditions”.] [Do not accept “at s.t.p.”]

[Allow (3) for “the molar volume at s.t.p. is 22.4 litres.”]

(ii) WHAT **1.069 – 1.10 m<sup>3</sup>** [Accept 1.1 but not greater] (9)

$2000 \div 44^* = 45.4 / 45.5 \text{ mol} \quad (3)$ <p style="margin: 0;"><i>[* addition must be shown for error to be treated as slip.]</i></p> $V = \frac{nRT}{P} = \frac{45.4/45.5 \times 8.3 \times 290}{1.01 \times 10^5} \quad \text{[or other correct form]} \quad (3)$ $= 1.069 - 1.10 \quad (3)$
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$2000 \div 44^* = 45.4 / 45.5 \text{ mol} \times 22.4 = 1017 / 1019 \text{ litres} \quad (3)$ <p style="margin: 0;"><i>[* addition must be shown for error to be treated as slip.]</i></p> $V = \frac{1.01325/1.013/1.01/1.0 \times 10^5 \times 1017/1019 \times 290}{1.01 \times 10^5 \times 273} \quad (3)$ <p style="margin: 0;"><i>[or other correct form]</i></p> $= 1069 - 1100 \text{ litres (1.069 - 1.10 m}^3) \quad (3)$
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WHAT: **0.182 kg / 182 g** [or answers rounding off to these figures] (6)

$45.4 / 45.5 \times 4 \quad (3) = 182 \text{ g} / 0.182 \text{ kg} \quad (3)$
---

(iii) GIVE: **stronger intermolecular (London dispersion, Van der Waals', dipole-dipole) forces (attractions) / higher mass / bigger molecules / polarity of C to O bond / has more electrons** (3)  
[To allow opposite points Helium must be mentioned.]

Question 10 continued.

(c) (i) HOW: **it decreases** (4)

(ii) ASSIGN: 1<sup>st</sup> equation: oxidation number of Br in Br<sub>2</sub> = **0** (3)

oxidation number of Br in Br<sup>-</sup> = **-1** (3)

2<sup>nd</sup> equation: oxidation number of Cl in Cl<sub>2</sub> = **0** (3)

oxidation number of Cl in Cl<sup>-</sup> = **-1** (3)

[The oxidation numbers may be written under the appropriate formulas]

BALANCE: Cl<sub>2</sub> + SO<sub>3</sub><sup>2-</sup> + H<sub>2</sub>O → 2Cl<sup>-</sup> + SO<sub>4</sub><sup>2-</sup> + 2H<sup>+</sup> (6)

[Do not insist on correct formulas (they are given). (6) or (0) for balancing numbers.

Accept only the smallest correct integral balancing numbers (2 & 2) – not multiples.]

(iii) WHY: **increasing atomic radius (size) / increase in number of shells / atoms get bigger / increase in shielding (screening) / decrease in electronegativity (attraction for electrons)** (3)

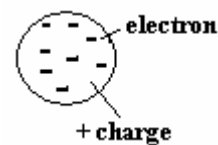
## QUESTION 11

- (a) (i) DESCR: **positively charged sphere (ball) // electrons\* embedded (scattered, dotted, placed at random) in it** (4 + 3)

[\*The word “electron(s)” required in description or diagram.]

Marks can be got from a labelled diagram such as:

[Allow 3 marks for “plum pudding” unqualified]



- (ii) STATE: *first observation:* **deflection** of alpha particles (3)  
*second observation:* alpha particles **reflected (rebounded , bounced back, came straight back)** (3)

EXPL: *first observation:* particles **passed close to small, positive mass (charge)** (3)  
*second observation:* particles **collided with small, very dense mass (material, nucleus, point)** (3)

[The explanations for the first and second observations must be given separately, or else it must be absolutely clear from the candidate’s answer which observation is being explained.]

- (iii) COPY: 
$$\begin{array}{ccccccc} 210 & & 206 & & 4 & & \\ \text{Po} & \rightarrow & \text{Pb} & + & \text{He} & & \\ 84 & & 82 & & 2 & & \end{array}$$
 Both Pb and 82: (3)  
 206: (3)

[Not necessary to write the equation. Accept  $x = 82, y = 206, z = \text{Pb}$  *or* 82, 206, Pb].

- (b) (i) EXPL: provides (supplies, gives) energy **for splitting (fission) of chlorine molecules (Cl<sub>2</sub>) // into free radicals (free atoms, Cl<sup>•</sup>)** (4 + 3)

[If “molecules” is stated for the first part, “free” is not required for the second part.]

or **homolytic fission (4) of chlorine (Cl<sub>2</sub>) molecules (3)**

or **Cl<sub>2</sub> → Cl<sup>•</sup> + Cl<sup>•</sup> (7)** [Equation without dots (4)]

- (ii) NAME: **chloromethane / methyl chloride // hydrogen chloride** (2 x 3)  
 [Not hydrochloric acid, but do not treat as a contradiction]

- (iii) ACC: **two CH<sub>3</sub><sup>•</sup> combine** to give ethane / **CH<sub>3</sub><sup>•</sup> + CH<sub>3</sub><sup>•</sup> → C<sub>2</sub>H<sub>6</sub>** (6)  
 [or the same in words]

- (iv) NAME: **ionic addition / electrophilic addition** (3)

- (v) GIVE: **solvents / dry cleaners / paint strippers / anaesthetics / organic synthesis (making of plastics) / refrigerants / flame retardants** (3)



Question 11 continued.

(c) A

- (i) STATE: **respiration / combustion (burning) / decomposition (decay) / melting ice-caps** (4)  
[Accept “exhaling” for “respiration”; accept “car emissions” for combustion.]
- (ii) WHAT: assessing (giving, stating) its influence on the greenhouse **effect relative to (compared with) carbon dioxide // comparing (measuring, giving, stating) the greenhouse effect of different gases** (6)
- (iii) NAME: **water // methane // CFC(s) // HCFC(s) // HFC(s) // chloromethane // chloroethane // dinitrogen oxide (nitrogen (I) oxide, nitrous oxide) // PFC(s) // ozone // sulphur hexafluoride // sulphur dioxide {sulphur(IV) oxide}, // nitrogen dioxide {nitrogen(IV) oxide} // nitrogen monoxide {nitric oxide, nitrogen(II) oxide} // carbon monoxide (or formulas) ANY TWO:(2 x 3)**
- (iv) WHAT: **carbonate\* ion ( $\text{CO}_3^{2-}$ ) // hydrogencarbonate\* ion ( $\text{HCO}_3^-$ ) // carbonic acid ( $\text{H}_2\text{CO}_3$ ) // hydronium ion ( $\text{H}_3\text{O}^+$ ) / hydrogen ion ( $\text{H}^+$ ) ANY THREE: (3 x 3)**  
caution – single solidus!  
[\* Do not accept salts such as “sodium carbonate” or “calcium hydrogencarbonate”.]

**B**

- NAME: *aluminium:* **metallic** crystal  
*sodium chloride:* **ionic** crystal  
*graphite:* covalent **macromolecular** crystal (3 + 2 + 2)
- EXPLAIN: (i) **outer (valence, highest energy) electrons delocalised (form cloud)** (3)  
which **are free to move** when a potential difference is applied (3)
- (ii) **ions attracted to polar water molecules / ion-dipole interactions (forces, attractions) / ions become hydrated** (6)  
[Marks could be got from a good diagram]
- (iii) **forces between layers of carbon atoms weak (Van der Waals', London)** (3)  
**because of distance** between them / allowing **layers to slide over one another** (3)

