



Coimisiún na Scrúduithe Stáit  
State Examinations Commission

**LEAVING CERTIFICATE 2009**

**MARKING SCHEME**

**CHEMISTRY**

**HIGHER LEVEL**





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*State Examinations Commission*

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## **MARKING SCHEME**

### **CHEMISTRY**

#### **HIGHER LEVEL**

## 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. There is a deduction of one mark for each arithmetical slip made by a candidate in a calculation.

## Outline Marking Scheme

### Section A [At least two questions must be answered from this section]

- (a) Why: 5; (b) Why must: 3, Why was: 3, What: 3; (c) Describe: 3, 3, 3, Why: 3; (d) Explain: 2 x 3; (e) (i): 6, (ii): 6, (iii): 6.
- (a) Give: 3, What: 2; (b) Write 3, Term: 3; (c) State: 3 x 3; (d) Give: 3, Describe: 3; (e) What: 3, Test: 3, 3; (f) What: 3, Write: 2 x 3; (g) Give: (i): 3, (ii): 3.
- (a) Describe: 2, 3, 3, 3; (b) Which: 3, What: 3; (c) Other: 3, Which: 3; (d) Describe: 3, 3, 3; (e) Write: 3, 3, What: 3, 3; (f) Suggest: 3, 3.

### Section B

- (a) Name: 3, Particle: 3; (b) What: 6; (c) State: 3, 3; (d) Define: 3, 3; (e) Define: 6; (f) Calculate: 6; (g) Identify: 6; (h) Draw: 2 x 3; (i) Complete: 3, 3; (j) Identify: (i): 3, (ii) 3; (k) **A**: 6, **B**: 3, 3.
- (a) Define: 5, 3; (b) Graph: 4 x 3; (c) (i): 2 x 3, (ii): 3, 3, (iii): 3, 3; (d) Write: 3, State: (i): 3, (ii): 3, Explain: 3.
- (a) Define: (i): 4, (ii): 4; (b) Give/Explain: 6 + 3; (c) Identify: 3, State: 3, Draw: 3 x 3; (d) Name: 2 x 3; (e) Calculate: 12.
- (a) (i) Describe: 5 + 2 x 3, (ii) What: 3, (iii) What: 3, (iv) Why: 3, How: 3; (b) (i) What: 6, Stage: 3, (ii) What: 2 x 3, 3, Calc: 9.
- (a) Give: 3, 3, 3, 3; (b) Name, Compound: 6 + 3; (c) Which 3, Other 3; (d) Describe 3, Write: 3, 3, Name 3, Express 3; (e) Draw 5, Label 3.
- (a) Explain: (i): 5, (ii): 3, Describe: 3, 3, Effect: (i): 3, (ii): 3, (iii): 3; (b) State: 3, Name: 2 x 3, Type: 3, Explain: 6, Poison: 3, Give: 3, 3.
- (a) State: 4, 3, Give: 2 x 3, Deviate: 2 x 3, How: 6.  
(b) Define 4, (i): 3, (ii): *anode*: 3, 3, *cathode*: 3, 3, (iii): 6.  
(c) (i): 4 + 3, (ii): 3, 3, 3, (iii): 9.
- (a) (i) Find: 4, (ii) Deduce: 3, Explain: 3, (iii): Identify: 3, (iv): Write: 6, (v): State: 3, Justify: 3.  
(b) (i): Use: 7, (ii): EPRT: 2 x 3, Explain: 3, (iii): What: 3, 3, Draw: 3.  
(c) **A** (i): Why: 4, (ii): Explain: 3, What 3, (iii): Write: 3, 3, Explain: 3, Give: 3, 3.  
(c) **B** Write: (i): 4 + 3, (ii): 3, (iii): State: 2 x 3, (iv): Give: 3, (v): Give: 3, (vi): Identify: 3.

## SECTION A

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

### QUESTION 1

(a) WHY: **to prevent anaemia / for haemoglobin / for red corpuscles / oxygen transport / specific reference to blood disorder / needed for the blood** (5)

*[No marks for the word 'anaemia' on its own. Must have more e.g. 'prevent anaemia', 'for anaemia', 'treat anaemia'. Allow 3 marks for 'iron deficiency' or 'essential element']*

(b) WHY MUST: **not primary standard / to find concentration / reagent (KMnO<sub>4</sub>) impure** (3)

WHY WAS: **unstable / decomposed / affected by light (heat, acids, bases, Mn<sup>2+</sup>, MnO<sub>2</sub>) / reacts with water** (3)

WHAT: **ammonium iron(II) sulfate / sodium ethanedioate (oxalate) / ethanedioic (oxalic) acid / excess iodide => iodine titrated with thiosulfate** *[Name or formula]* (3)

*[If formulas of ions, e.g. of thiosulfate, are used, the correct charges must be shown]*

(c) DESCRIBE: **tablets crushed and dissolved** (3)

**transferred (added, poured, etc.) with rinsings to 250 cm<sup>3</sup> volumetric flask** (3)

**bottom of meniscus on mark / brought to mark** (3)

*[If none of these (3)s has been awarded, allow (3) for any one of the following: "use of mortar and pestle", "rinse (wash) into beaker", "stir to dissolve", "transfer to flask using funnel (glass rod)", "flask on level surface (mark at eye-level)". "add to flask drop-by-drop {using dropper (pipette, wash bottle), top up carefully}", "invert volumetric flask (mix, shake – but not swirl)".]*

WHY: **prevents oxidation by air (atmosphere, oxygen) of iron(II) {Fe(II), Fe<sup>2+</sup>, iron, Fe} / prevents iron(II) {Fe(II), Fe<sup>2+</sup>} going to iron(III) {Fe(III), Fe<sup>3+</sup>} due to air (atm., oxygen)** *[accept 'prevents hydrolysis to readily air-oxidised species']* (3)

(d) EXPLAIN: **to ensure complete conversion (reduction) of MnO<sub>4</sub><sup>-</sup> {manganate(VII), Mn(VII), Mn<sup>7+</sup>} to Mn<sup>2+</sup> {manganese(II), Mn(II)}** //

**to prevent formation of manganese(IV) {Mn(IV), Mn<sup>4+</sup>, MnO<sub>2</sub>, states – which may be specified – other than manganese(II)}** / **to prevent formation of a brown ppt** (2 x 3)

*If neither of the above (3)s has been obtained, give (3) marks for "to allow complete reduction (not oxidation or reaction)"*

(e) (i) **0.0375 M** (6)

$(25 \times M) / 5 = (18.75 \times 0.01) / 1$ (3)
M = 0.0375 (3)

(ii) **0.525 g** *[Allow A<sub>r</sub> of iron from Maths Tables]* (6)

$0.0375 \times 56 = 2.1$ (3)
$2.1 \div 4 = 0.525$ (3)

(iii) **32.3 %** *[Apply –1 for rounding off in (i), (ii), (iii). Apply once only.]* (6)

$0.525 / (0.325 \times 5) / 0.325$ (3)
$\times 100 = 32.3$ (3)

## QUESTION 2

(a) GIVE: **aluminium oxide / alumina / Al<sub>2</sub>O<sub>3</sub>** (3)

WHAT: **white** (2)

(b) WRITE: **C<sub>2</sub>H<sub>5</sub>OH → C<sub>2</sub>H<sub>4</sub> + H<sub>2</sub>O** (3)

TERM: **elimination** [*Accept “dehydration”*] [*Cancel with second (incorrect) reaction type*] (3)

(c) STATE: **keep gas from flame / air-tight stopper / secure assembly / don’t use first gas jar // safety screen / glasses (goggles) / protective clothing / tie hair back // before heat removed take tube from water / disconnect tube / dismantle apparatus // use tongs / gloves // avoid inhaling glass wool / wear mask** (3)

ANY THREE: (3 x 3)

(d) GIVE: **calcium(II) dicarbide / calcium carbide / carbide / calcium acetylide / CaC<sub>2</sub>** (3)

DESCRIBE: **black / dark / grey / off-white / grey black / sandy / buff / brown-grey / dirty solid** (3)  
[*“Give” & “Describe” not linked*]

(e) WHAT: **double (triple, multiple) carbon-to-carbon bond present / undergoes addition** (3)

TEST: **add bromine water / bromine soln / Br<sub>2</sub> / acidified potassium manganate(VII) soln / acidified KMnO<sub>4</sub> soln / H<sup>+</sup> + MnO<sub>4</sub><sup>-</sup> soln / KMnO<sub>4</sub> + H<sub>2</sub>SO<sub>4</sub> soln** (3)

**decolorises / changes to colourless** (not ‘clear’) (3)  
[*The two (3)s are not linked so may be given separately*]

(f) WHAT: **ethene less (ethyne more) luminous (smoky, sooty)** (3)

[*Allow “ethene has yellow flame whereas ethyne’s is sooty (smoky)”*]  
[*Accept ‘ethyne produces soot’; otherwise comparing ethyne with ethene is required and cannot be assumed.*]

WRITE: **C<sub>2</sub>H<sub>4</sub> + 3O<sub>2</sub> → 2CO<sub>2</sub> + 2H<sub>2</sub>O /**  
**C<sub>2</sub>H<sub>2</sub> + 2½O<sub>2</sub> → 2CO<sub>2</sub> + H<sub>2</sub>O /**  
**2C<sub>2</sub>H<sub>2</sub> + 5O<sub>2</sub> → 4CO<sub>2</sub> + 2H<sub>2</sub>O**

FORMULAS (3) BALANCING (3)

(g) GIVE: (i) *ethene*: manufacture of **polythene {poly(ethene), plastic, polymer}** / make **ethane-1,2-diol (ethylene glycol, antifreeze)** / make **polyester (terylene)** / make **chloroethene (vinyl chloride)** / make **PVC {polyvinylchloride, poly(chloroethene)}** / make **ethanol** / make **phenylethene (styrene)** / make **poly(phenylethene) {polystyrene}** / **ripening fruit** (3)

[*Do not accept general terms e.g. “medicine”, agriculture”, “industry”, but do not cancel them with an acceptable use. Accept IUPAC polymer names without brackets.*]  
[*Allow “growth hormone”, “growth promoter”*]

(ii) *ethyne*: **oxyacetylene flame (torch – not blowtorch)** / **cutting metals / welding metals** / make **ethanal (propanone, propan-2-ol, polymers, plastics, pesticides)** / **fuel for lamps** [not ‘fuel’ on its own] (3)

[*Do not accept general terms e.g. “medicine”, agriculture”, “industry”, but do not cancel them with an acceptable use.*]

### QUESTION 3

- (a) DESCRIBE: Introduce **salt into (on, in) flame** of bunsen burner (2)  
using **platinum (nichrome) wire (probe)** / using **soaked (dipped) splint (lollipop stick)\*** (3)  
**sodium (Na) gives orange (yellow) flame** (3)  
**potassium (K) gives lilac (violet, purple\*\*)** flame *[\*\*Do not allow 'red' or 'pink']* (3)  
*[\*Allow "inoculating loop" or "spatula"]*
- (b) WHICH: **KCl / potassium chloride / the chloride (Cl<sup>-</sup>)** / *[Not "chlorine ion"]* (3)  
WHAT: **white precipitate (ppt)** soluble in ammonia solution (3)
- (c) OTHER: **iron(II) sulfate / ferrous sulfate / FeSO<sub>4</sub>** solution (3)  
WHICH: **KNO<sub>3</sub> / potassium nitrate / the nitrate ion (NO<sub>3</sub><sup>-</sup>)** (3)
- (d) DESCRIBE: To salt solution add ammonium **molybdate** [(NH<sub>4</sub>)<sub>6</sub>Mo<sub>7</sub>O<sub>24</sub>·4H<sub>2</sub>O, (NH<sub>4</sub>)<sub>2</sub>MoO<sub>4</sub>] solution (3)  
and a few drops of concentrated **nitric acid** and warm gently (3)  
**yellow precipitate (ppt)** formed (3)  
*[The (3)s for molybdate and nitric acid may be awarded in either order, but the (3) for yellow precipitate only to be awarded when molybdate and/or nitric acid do not come after it.]*
- (e) WRITE: **Na<sub>2</sub>SO<sub>3</sub>(.7H<sub>2</sub>O) + BaCl<sub>2</sub> → BaSO<sub>3</sub> + 2NaCl (+ 7H<sub>2</sub>O) /**  
**Na<sub>2</sub>SO<sub>4</sub>(.10H<sub>2</sub>O) + BaCl<sub>2</sub> → BaSO<sub>4</sub> + 2NaCl (+ 10H<sub>2</sub>O) /**  
**SO<sub>3</sub><sup>2-</sup> + Ba<sup>2+</sup> → BaSO<sub>3</sub> / SO<sub>4</sub><sup>2-</sup> + Ba<sup>2+</sup> → BaSO<sub>4</sub>** FORMULAS (3) BALANCING (3)  
*[Accept BaSO<sub>3</sub>.7H<sub>2</sub>O & BaSO<sub>4</sub>.10H<sub>2</sub>O on the right. If water molecules on left but not on right, give (3) only – for formulas. Accept a mixture of ions and full formulas, if correct.]*
- WHAT: ppt **dissolved** => **Na<sub>2</sub>SO<sub>3</sub>.7H<sub>2</sub>O (Na<sub>2</sub>SO<sub>3</sub>, SO<sub>3</sub><sup>2-</sup>, sulfite)** (3)  
ppt **undissolved** => **Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O (Na<sub>2</sub>SO<sub>4</sub>, SO<sub>4</sub><sup>2-</sup>, sulfate)** (3)  
*[Both are required; if one is correct and the other is omitted, the second (3) cannot be given on the basis of an assumption]*
- (f) SUGGEST: add dilute **acid** (3)  
**carbon dioxide (CO<sub>2</sub>) evolved / gas turns limewater milky** (3)  
OR  
add **magnesium sulfate (MgSO<sub>4</sub>)** solution (3)  
**no precipitate (ppt)** observed (3)  
*[If none of these marks are given allow (3) for identifying NaHCO<sub>3</sub>, HCO<sub>3</sub><sup>-</sup>]*

## 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.

(a) NAME: Robert Millikan (3)  
 PARTICLE: electron (3)

(b) WHAT: neutron changes to proton /  
 number of neutrons decrease(s) by 1, number of protons increase(s) by 1 (6)  
 [Can be got for :  ${}_1n^0 \rightarrow {}_1p^+$ ] [Do not accept 'atomic number' for 'number of protons']  
 [May not be given for example]

(c) STATE: not possible to measure the exact position (location) and momentum (energy, velocity) of  
 electron (3)  
 in atom simultaneously (at same time) (3)

(d) DEFINE: average energy required to break a bond (1 mole of bonds) (3)  
 and to separate the atoms / into separate (single) atoms / in the gaseous state (3)

(e) DEFINE: acid & base differing by proton ( $H^+$ ) /  
 acid donating (losing) proton ( $H^+$ ) to form conjugate base /  
 base accepting (gaining) proton ( $H^+$ ) to form conjugate acid (6)

(f) CALCULATE: 1.6 (6)  

$$\boxed{-\log 0.025 \quad (3) \quad = \quad 1.6 \quad (3)}$$

(g) IDENTIFY: calcium carbonate /  $CaCO_3$  [Accept 'magnesium carbonate' or ' $MgCO_3$ '] (6)

(h) DRAW:  $O-H / OH // C=O / C=O / COOH // CH_2OH // CHOH // COH // SO_3H$   

$$\begin{array}{c} | \quad | \\ O-H \quad OH \end{array}$$
  
 ANY TWO: (2 x 3)

[Accept "R-F-Group" but not formula of compound containing group, unless group is indicated. However, give (3) if two formulas of compounds containing different correct functional groups are given.]

(i) COMPLETE:  $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$  /  $C_2H_6 + 2Cl_2 \rightarrow C_2H_4Cl_2 + 2HCl$  /  
 $C_2H_6 + 3Cl_2 \rightarrow C_2H_3Cl_3 + 3HCl$  /  $C_2H_6 + 4Cl_2 \rightarrow C_2H_2Cl_4 + 4HCl$  /  
 $C_2H_6 + 5Cl_2 \rightarrow C_2HCl_5 + 5HCl$  /  $C_2H_6 + 6Cl_2 \rightarrow C_2Cl_6 + 6HCl$   
 FORMULAS (3) BALANCING (3)

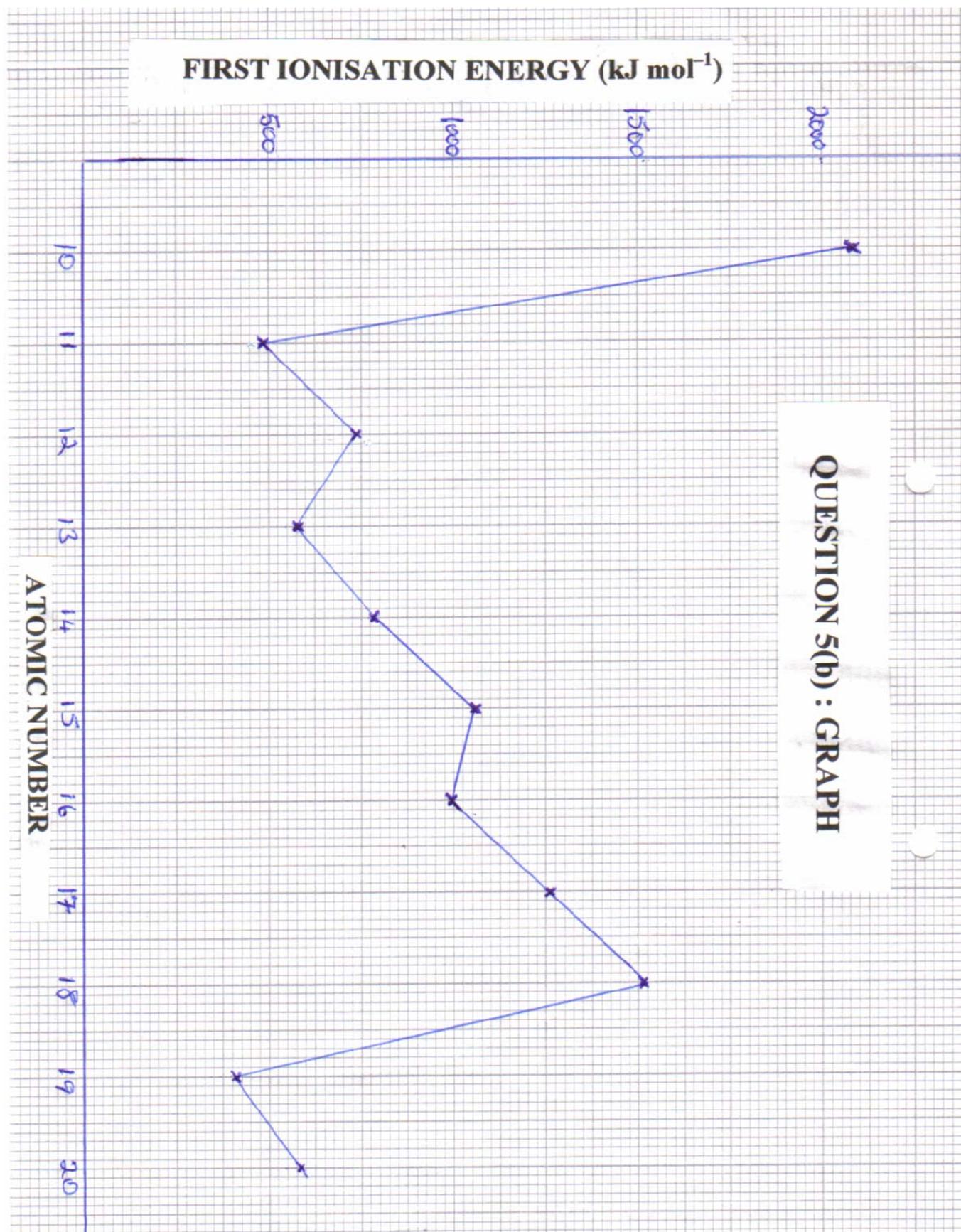
(j) IDENTIFY: (i) oxidizing / oxidizing agent [not 'oxidation'] (3)  
 (ii) toxic / poisonous (3)

(k) A polymerization of alkenes (or named alkene) / alkene (or named alkene) polymer  
 manufacture (production) / polymerization at low pressures (atmospheric pressure)  
 [Allow (3) for 'polymerisation'. Accept IUPAC polymer names without brackets.] (6)

B (i)  $2NH_3 + CO_2 \rightarrow (NH_2)_2CO + H_2O$  /  
 (ii)  $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$  /  $2NH_3 + 2^{1/2}O_2 \rightarrow 2NO + 3H_2O$  /  
 (iii)  $Ca(OH)_2 + MgCl_2^* \rightarrow Mg(OH)_2 + CaCl_2$  /  $Ca(OH)_2 + Mg^{2+} \rightarrow Mg(OH)_2 + Ca^{2+}$   
 [\*Accept other magnesium halides e.g.  $MgBr_2$ .]  
 FORMULAS (3) BALANCING (3)

## QUESTION 5

- (a) DEFINE: The minimum energy to **remove most loosely-bound (highest energy, outermost) electron** (5)
- from an **isolated (gaseous) atom in its ground (lowest energy) state** /  
from **1 mole of isolated (gaseous) atoms in their ground (lowest energy) state** (3)
- (b) GRAPH: **axes correctly labeled // axes correctly scaled // points correctly plotted // graph correctly drawn [SEE GRAPH ON NEXT PAGE]** (4 x 3)
- [Allow broken lines in graph. Deduct (3) if not on graph paper. Award plotting (3) if all the points except one are correctly plotted.]*
- (c) (i) **increased nuclear charge / increase in protons / increase in atomic number // decrease in atomic radius // no increase in shielding (screening) by inner shells** ANY TWO: (2 x 3)
- [Give (6) for increase in effective nuclear charge.]*
- (ii) **increased stability of element 12 due to full outer sublevel (subshell) / stability due to electron being removed from full sublevel (subshell)** (3)
- increased stability of element 15 due to half-full p sublevel (subshell) / stability due to three singly-occupied (half-full) p orbitals** (3)
- [If candidate has 'stability due to half-full sublevel (subshell)' or 'stability due to three singly-occupied (half-full) orbitals' but does not mention p, the (3) may be given if  $3p^3$  or  $3p_x^1 3p_y^1 3p_z^1$  are ALSO present in the answer. Note that the parts in words are essential.]*
- (iii) **element 18 stable due to outer octet (eight in outer shell) / stable octet / noble gas config / outer sublevel (subshell) full / outer (electron being removed from)  $3s^2 3p^6$**  (3)
- element 19 has outer electron further from nucleus (in a new shell / more screened) / electron removed from next ( $4^{\text{th}}$ ) shell / electron removed from 4s – can only be given if full sp configuration of potassium is shown in candidate's work.** (3)
- (d) WRITE:  **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$  /  $[\text{Ar}]4s^1$**  *[Allow with subscripts instead of superscripts.]* (3)
- STATE: (i) **6 sublevels** (3)
- (ii) **10 orbitals** (3)
- EXPLAIN: **4s sublevel (subshell) lower in energy than 3d** (3)



*['First' & ' $\text{kJ mol}^{-1}$ ' not required in 'First ionization energy ( $\text{kJ mol}^{-1}$ )]*

## QUESTION 6

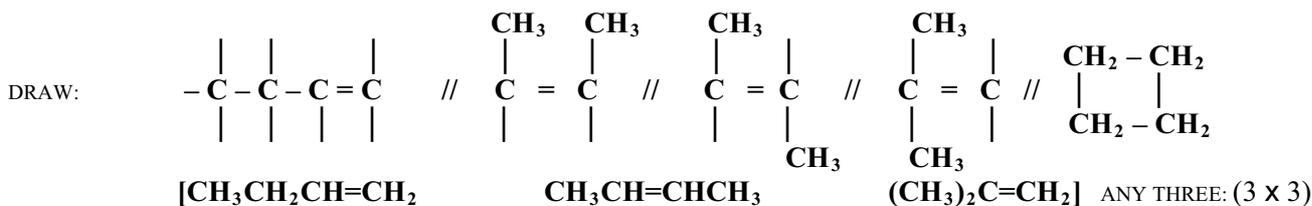
- (a) DEFINE: (i) compounds of\* **carbon (C) and hydrogen (H)** only (4)  
 [\*if “containing” is used, then “only” has to accompany it]
- (ii) compounds with **same molecular\* formula** but **different structural formulas (structures, atomic arrangements)** [\*not ‘chemical’] (4)

- (b) GIVE: home (central, domestic) **heating** / used as **paraffin oil / jet (aviation, aircraft) fuel / tractor fuel (TVO) / bus fuel / rocket fuel / storing reactive elements (metals e.g. alkali metals; non-metals e.g. white phosphorus) / solvent / lubricant / lighting (paraffin lamps) / cooking / produce petrol (gasoline) / camping stoves**  
 [*Note: medicinal liquid paraffin and paraffin wax (candles) are not kerosene derivatives.*]

EXPLAIN: greater demand for **shorter chains (smaller molecules, kerosene chains too long) // useful products // lighter fractions // increased octane number // production of raw materials (alkenes – or named alkene, monomers, compounds) for making polymers (plastics, petrochemicals)** (6 + 3)  
 [*The first correct point from GIVE or EXPLAIN gets (6).*]

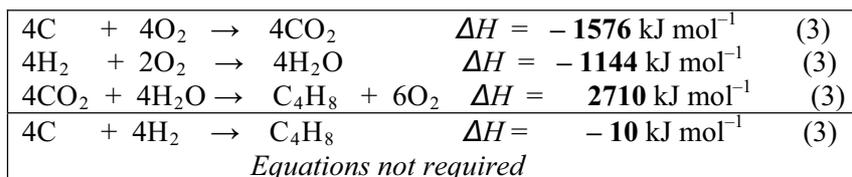
- (c) IDENTIFY: **heptane / C<sub>7</sub>H<sub>16</sub> / CH<sub>3</sub>(CH<sub>2</sub>)<sub>5</sub>CH<sub>3</sub>** (3)

STATE: **octane number: 0 / zero (naught, nought)** [*IDENTIFY & STATE are linked*] (3)

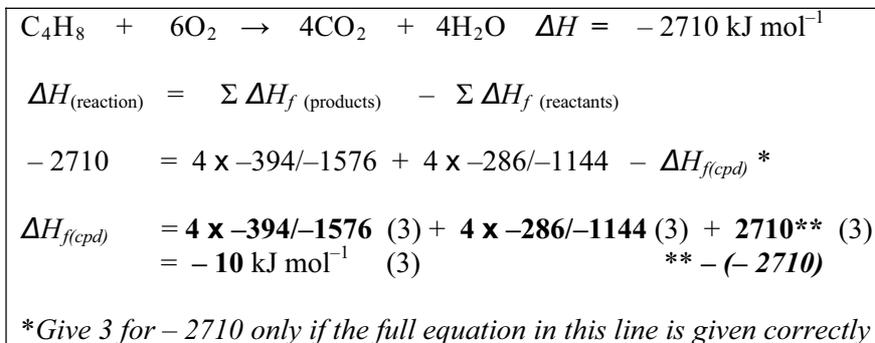


- (d) NAME: **isomerisation // reforming (dehydrocyclisation, cyclodehydrogenation)** (2 x 3)

- (e) CALCULATE: **- 10 kJ mol<sup>-1</sup>** (12)



OR



## QUESTION 7

(a) (i) DESCRIBE: **settlement (sedimentation, allow to settle)** //

**flocculation (coagulation, aggregation, clumping, joining together of particles) / adding aluminium sulfate {aluminium chloride, aluminium(III), alum, iron(III) sulfate (ferric sulfate), iron(III) chloride (ferric chloride), iron(III), polyelectrolytes, lime}** [*Accept correct formula*] //

**decanting** the clear water / **allow the water to overflow** //

**filtration / passing through sand** and gravel beds

ANY THREE: (5 + 2 x 3)

(ii) WHAT: **chlorination (add chlorine, add Cl<sub>2</sub>) / ozone** (3)

(iii) WHAT: **corrosion (erosion) in system / hardness / deposits (clogging, narrowing, blocking) of pipes / damage to pipes / salty taste / tooth decay** (3)  
[*Allow "chalky taste", "bad taste"*]

(iv) WHY: **lead is poisonous (toxic)** (3)  
[*Allow 'damage to internal organs' or 'damage to a named correct internal organ e.g. brain, liver, kidney' but not vague answers e.g. 'damage to health'. Allow 'causes birth defects'.*]

HOW: **precipitation / adsorption / absorption / ion exchange (deionising) / complexation / add hydrochloric acid (HCl) / add sulfuric acid (H<sub>2</sub>SO<sub>4</sub>)** (3)  
[*Do not accept 'flocculation' or 'distillation'.*]

(b) (i) WHAT: **nitrates (nitrogen compounds) // phosphates (phosphorus compounds) // household detergents // slurry // untreated sewage // fertilizer run-off // silage effluent // farm effluent (run-off, waste)** (6)  
ANY ONE:

STAGE: **tertiary stage** [*The term 'tertiary' is essential*] (3)

(ii) WHAT: **conditions: in the dark // at 20 °C (293 K)** (2 x 3)

**duration: 5 days** (3)

CALC: **510 ppm** (9)

$$9.8 - 4.7 = 5.1 \quad (3)$$

$$5.1 \times \frac{5}{0.05} / 5.1 \times \frac{5000}{50} / 5.1 \times 100 \quad (3)$$

$$= 510 \quad (3)$$

## QUESTION 8

- (a) GIVE: **A = ethanol** (3)  
**B = ethanal** (3)  
**C = ethanoic acid** (3)  
**D = ethyl ethanoate** (3)

*[If not designated A, B, C, D, the order in the question should be followed. If only one name is given, and it is undesignated, assume it is the first.]*

- (b) NAME: saturated, aliphatic **aldehydes / alkanals**
- COMPOUND: **benzaldehyde / benzenecarbaldehyde / benzenecarboxaldehyde / benzoic aldehyde / phenylmethanal / oil of bitter almonds** (6 + 3)  
*[Name required]*

- (c) WHICH: **A / ethanol / ethyl alcohol** (3)

OTHER: **B / ethanal / acetaldehyde** (3)

- (d) DESCRIBE: **effervescence / fizzing / bubbling / gas (CO<sub>2</sub>) produced (evolved, given off) / sodium carbonate (solid, powder) dissolves / clear solution formed** (3)

WRITE: **2CH<sub>3</sub>COOH + Na<sub>2</sub>CO<sub>3</sub> → 2CH<sub>3</sub>COONa + H<sub>2</sub>O + CO<sub>2</sub> [or H<sub>2</sub>CO<sub>3</sub>]**  
 FORMULAS: (3) BALANCING: (3)

NAME: **vinegar** (3)

EXPRESS: **6 % (w/v)** (3)

$60^* \div 10 = 6 \quad (3)$ <p><i>*addition must be shown for error to be treated as slip.</i></p>
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- (e) DRAW: (5)



*[Accept "CH<sub>3</sub>" for methyl group and "CH<sub>2</sub>CH<sub>3</sub>" for ethyl group; if "C<sub>2</sub>H<sub>5</sub>" used for ethyl group, give 3 only.]*

LABEL: **all three tetrahedral carbon atoms clearly labelled or identified** (3)

*[DRAW & LABEL: These are linked. The (3) marks for the three tetrahedral carbons required in LABEL may only be awarded when the formula of ethyl ethanoate in DRAW is correct.]*

## QUESTION 9

- (a) EXPLAIN: (i) minimum **energy** required for **colliding particles (molecules) to react** / **energy needed for colliding particles (molecules) to initiate reaction** / minimum **energy** needed for **effective collisions** between particles (molecules) (5)  
*[Allow (3) for 'energy (required) for reaction to take place']*  
*[Do not accept  $E_{Act}$  diagram]*
- (ii) **reaches (exceeds) activation energy** / **results in (brings about, causes) reaction** between colliding particles (molecules) / **results in product** formation (3)
- DESCRIBE: **mix (add one solution to the other)** and start clock (3)  
 stop clock and **note time when cross (print, etc.) becomes invisible (obscured by the precipitate)** when viewed through the solution. (3)
- EFFECT: (i) small (slight, tiny, < 5 %) **increase** (3)  
 (ii) large (big, substantial, > 50 %) **increase** in effective collisions (3)  
 (iii) **no effect / none** (3)
- (b) STATE: **wire (Pt) glows / flame / popping sound / odour of methanal** (3)
- NAME: **methanal // hydrogen // water** *[Accept "carbon monoxide"]* ANY TWO: (2 x 3)
- TYPE: **heterogeneous / surface** *[Accept "surface adsorption (absorption)" but not "hetero"]* (3)
- EXPLAIN: **lowers activation energy / reactants adsorbed / reactants brought closer on surface / higher concentration on surface / reactants occupy active sites on surface / chemisorption (chemical attachment) / bond stretching (loosening, weakening) / reactant (reagent) oriented correctly for reaction / activated complex formed** on surface of catalyst. (6)
- POISON: **preferentially adsorbed (chemisorbed, chemically attached) on catalyst / blocks occupiers) active sites / does not desorb / forms bond(s) with catalyst, preventing (stopping, blocking) other reaction(s)** (3)
- GIVE: **reactant(s)** (3)  
**catalyst** (3)

Hydrogen peroxide ( $H_2O_2$ )	Manganese(IV) oxide (manganese dioxide, $MnO_2$ )
Nitrogen ( $N_2$ ) & Hydrogen ( $H_2$ )	Iron (Fe) / Iron(III) oxide ( $Fe_2O_3$ )
Sulfur dioxide ( $SO_2$ ) & oxygen ( $O_2$ )	Vanadium(V) oxide ( $V_2O_5$ )
Ammonia ( $NH_3$ ) & oxygen ( $O_2$ )	Platinum/rhodium (Pt/Rh)
Ethanol ( $C_2H_5OH$ )	Aluminium oxide ( $Al_2O_3$ )
Ethanol ( $C_2H_5OH$ )	Platinum (Pt) / Copper (Cu) / Nickel (Ni)
Hydrogen ( $H_2$ ) & Oxygen ( $O_2$ )	Platinum (Pt)
Name/formula of cat. converter reactant	Platinum (Pt) / Palladium (Pd) / Rhodium Rh

*[Reactant and incorrect catalyst (3) (Note: enzymes are homogeneous.)*

*Reactant but no catalyst: Award (3) for the reactant if the reaction is normally catalysed.]*

## QUESTION 10

- (a) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (4)  
**under same conditions\* / at same temperature and pressure** (3)

[Allow (3) for 'the molar volume at s.t.p. is 22.4 litres'.]

[\*Do not accept 'under all conditions' or 'at s.t.p.' or 'at constant temp & pressure']

- GIVE: gases made up of **particles (molecules, atoms) in rapid, random, straight-line motion** // **volume of particles (molecules, atoms) zero (negligible) / molecules (particles, atoms) take up no (negligible) space // no forces of attraction or repulsion between molecules (particles, atoms) // collisions between molecules perfectly elastic (involve no energy loss) // average kinetic energy of molecules proportional to kelvin temperature** ANY TWO: (2 x 3)

- DEVIATE: have **intermolecular forces {attractions between particles (molecules, atoms, named correct intermolecular force) // molecules (particles, atoms) have volume (take up space, volume not negligible) // collisions not perfectly elastic** ANY TWO: (2 x 3)

- HOW: **1.5 mol** (6)

$1.8 \times 10^{24} \div 2 = 9 \times 10^{23} \text{ molecules (3)} \quad \div 6 \times 10^{23} = 1.5 \text{ moles (3)}$
--

- (b) DEFINE: **loss of electrons** (4)

- (i) **platinum / carbon (graphite)** (3)

- (ii) *anode:*  $\text{I}^- \rightarrow \frac{1}{2}\text{I}_2 + \text{e}^- / 2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$  FORMULAS: (3) BALANCING: (3)  
 [Electrons may be shown subtracted on the left. Neg. charge on e need not be shown.]

- cathode:*  $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^- / \text{H}_2\text{O} + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2 + \text{OH}^-$  FORMULAE: (3) BALANCING: (3)

[Electrons may be shown subtracted on the right. Neg. charge on e need not be shown.]

- (iii) colour of the **iodine** produced (6)

[Allow 3 for "correct colour : red, orange, yellow, brown or combinations of them" if iodine not stated]

- (c) (i) atoms of **same element (same atomic number, same number of protons) having different mass numbers (different numbers of neutrons)** (4 + 3)

- (ii) positive **ions (charged particles) separated (deflected, spread out)** [For diagram give (3)  
**based on (according to) relative mass(es) (charge-to-mass ratio)** not more than (3)] (3)  
 when moving **in a magnetic field** [Allow "weight" for "mass"] (3)  
 [Allow "between (electro)magnets" for "in a magnetic field"]

- (iii) **20.19** (9)

$90.5 \times 20 / 1810 \quad (3)$
$9.5 \times 22 / 209 \quad (3)$
$100.0 = 2019 \Rightarrow A_r = 20.19 \quad (3)$

[Alternative method: 90.5 % of 20 / 18.1 (3) + 9.5 % of 22 / 2.09 (3) = 20.19 (3)]

[Marks for 20.19 not awarded if answer is given rounded off. If candidate shows 20.19 and rounds off, 1 mark is lost. The earlier partial marks are still available if shown.]

### QUESTION 11

(a) (i) FIND:  $T = 573 \text{ K}$   $P = 1000 \text{ atm}$  [No need to designate numbers as T & P] (4)

(ii) DEDUCE: forward reaction is **exothermic** / **backward (reverse) reaction is endothermic** (3)

EXPLAIN: **more NH<sub>3</sub> (product) at lower temp / less N<sub>2</sub> (H<sub>2</sub>, reactants) at lower temp / more N<sub>2</sub> (H<sub>2</sub>, reactants) at higher temp / less NH<sub>3</sub> (product) at higher temp / forward reaction favoured at lower temp / backward (reverse) at higher temp / higher yield at low temperature / lower yield at high temperature** (3)

(iii) IDENTIFY: **high (building, maintenance) costs** / danger of **leaks** / danger of **explosions** (3)

(iv) WRITE:  $\frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$  [Square brackets essential] (6)

(v) STATE: **no effect / none** (3)

JUSTIFY: **forward and backward (reverse) rates equally affected** by catalyst / **rates increased but position of equilibrium unchanged** / **reaches equilibrium faster but yield unchanged** (3)

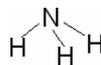
(b) (i) USE: (7)



[Correct shape not reqd. Accept all dots or all crosses. For bonds accept  $\times - \blacksquare$  ]

(ii) EPRT: **three bonding and one non-bonding (lone) pair / four electron (valence) pairs\*** // giving bond arrangement (shape of molecule) to be **pyramidal\*\*** [\*\*\* 'distorted tetrahedron' not acceptable for 'pyramidal' but does not cancel] (2 × 3)

[Tripod-like diagram acceptable for second (3).



Allow even if lone pair is shown.]

[\*\*Allow this (3) from correct diagram in (i) provided "lone pair" is mentioned in (ii)]

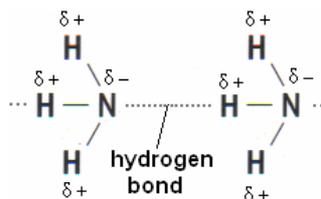
EXPLAIN: **greater repelling power (repulsion) of lone pair / lone pair pushes bonds closer together** [Allow "l.p.: b.p. > b.p.: b.p." or "l.p.: l.p. > l.p.: b.p. > b.p.: b.p." ] (3)

(iii) WHAT: **intermolecular (between molecules) attraction** [Can be got from diagram below or other suitable diagram.] (3)

involving slightly ( $\delta$ ) **positive (+) hydrogen (H) atom** and slightly ( $\delta$ ) **negative (-) atom {highly electronegative element(s)/atom(s), F, O, N}**

[Charges can be got from diagram below or other suitable diagram.] (3)

DRAW: (3)



[One hydrogen bond must be shown with  $\delta$  neg. charge on the N and  $\delta$  pos charge on the H. If unlabelled, it may be assumed that the dotted line (or line that is different from the other bonds e.g. in colour) is meant to be a hydrogen bond. Both molecules must be ammonia.]

Question 11 continued/

(c)

A (i) WHY: **ores very stable (hard to reduce) / metals (sodium) high (near top) of electro-chemical series [high (near top) of reactivity series, have low (high negative)  $E^{\circ}$  (standard electrode potential, standard reduction potential), have high standard oxidation potential] / electrons are the strongest (very strong) reducing agents** (4)

(ii) EXPLAIN: **to allow conduction (to allow electricity to flow, solid non-conducting) / to allow movement of ions (no movement of ions in solid)** (3)

WHAT: **to lower melting point (mp) of electrolyte / fluxing agent** (3)

(iii) WRITE:  $\text{NaCl} \rightarrow \text{Na} + \frac{1}{2}\text{Cl}_2$  /  $2\text{NaCl} \rightarrow 2\text{Na} + \text{Cl}_2$   
FORMULAS: (3) BALANCING: (3)

EXPLAIN: **separated by steel gauze (mesh) / floating sodium (Na) removed through pipe (tube) and chlorine ( $\text{Cl}_2$ ) extracted through hood** (3)

GIVE: *sodium*: **street lighting / coolant (heat exchanger) in nuclear reactors / making alloys (e.g. Na/Pb) / making lead tetraethyl {tetraethyl lead,  $\text{Pb}(\text{C}_2\text{H}_5)_4$ ,  $\text{PbEt}_4$ } / extraction of less electropositive metals (Ti, Zr, etc.) / drying organic solvents / producing potassium (rubidium, cesium) / making sodium hydride (NaH) / making sodium peroxide ( $\text{Na}_2\text{O}_2$ ) / measuring neutron radiation dosage** (3)

*chlorine*: **chlorination (water treatment) / disinfectant / bactericide / antiseptic / in swimming pools / making polymers (plastics, PVC) / making of chloroalkanes {CFCs, HCFCs, chloroalkenes, hydrogen chloride (HCl, hydrochloric acid) / other synthesis example / powerful oxidizing agent / weapon (poison gas, chemical warfare)** (3)

OR

B WRITE: (i)  $\text{O}_2 \rightarrow 2\text{O}^{\bullet}$  /  $\text{O}_2 \rightarrow \text{O}^{\bullet} + \text{O}^{\bullet}$  /  $\text{O}_3 \rightarrow \text{O}_2 + \text{O}^{\bullet *}$  //  
 $\text{O}_2 + \text{O}^{\bullet} \rightarrow \text{O}_3$  [*\*May not be awarded the marks for (ii)*] (4 + 3)

(ii)  $\text{O}_3 \rightarrow \text{O}_2 + \text{O}^{\bullet *}$  [*\*May not be awarded marks for (i)*] (3)

(iii) STATE: **more ultra-violet (uv) reaches earth // sunburn (skin damage) // skin cancer (melanoma, skin disease) // eye damage // damage to plants** ANY TWO: (2 x 3)

(iv) GIVE: **refrigerant (fridges) / air-conditioning / aerosol propellant for deodorants, insecticides / dry cleaning / solvents / fire extinguishers / expanded polymers (blowing agents) / burger cartons** (3)

(v) GIVE: **name or formula of any CFC** (3)  
[Any alkane with chlorine(s) and fluorine(s) substituting for the hydrogen atoms e.g.  $\text{CCl}_2\text{F}_2$  (dichlorodifluoromethane, CFC-12). Allow with Br instead of Cl]

(vi) IDENTIFY: **HCFCs (hydrochlorofluorocarbons) / HFCs (hydrofluorocarbons)** (3)  
[Accept "phostrex", a replacement for halon (contains bromine) in fire extinguishers.]



