CAMBRIDGE INTERNATIONAL EXAMINATIONS

Pre-U Certificate

MARK SCHEME for the May/June 2013 series

9791 CHEMISTRY

9791/02 Paper 2 (Part A Written), maximum raw mark 100

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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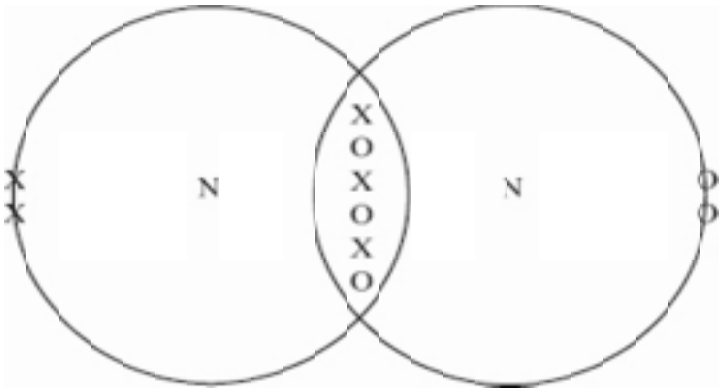
International Examinations

1 (a) (i) Dot-cross diagram where electrons from each atom are distinguishable; three shared pairs and one lone pair on each atom; no inner shell electrons shown.



[1]

(ii) Different or alternative structure for the same element (in the same physical state). [1]

(iii) Breaking bonds: $12 + (6 \times 198\,kJ\,mol^{-1}) = 1200\,kJ\,mol^{-1}$ (1)
Making bonds = $2 \times 485\,kJ\,mol^{-1} = 970\,kJ\,mol^{-1}$ (1)
Positive sign with correct answer (1)
Enthalpy change = $+230\,kJ\,mol^{-1}$ earns all 3 marks. [3]

(iv) Bond order in P_2^{2+} = 2 (accept 'double') (1)
Bond order in P_2^{+} = 2.5 or 5/2 (1) [2]

(b) (i) Energy (required) to *remove one electron* (1)
from (every atom in) a *mole of atoms* (1)
in the *gas* phase (1)
Allow 'mole of electrons from a mole of atoms'.
Do not allow 'molecules' or 'compound'. [3]

(ii) Outer electrons in silicon are further from the nucleus.
OR Si is a larger atom OR Si has larger atomic radius. (1)
There is greater shielding of the outer electrons in silicon compared to carbon. (1)
(Despite the additional protons in silicon) the outer electrons experience a reduced attraction to the nucleus OR the outer electrons are at higher energy. (1)
NB The statement "effective nuclear charge decreases down a group" is false: it increases. [3]

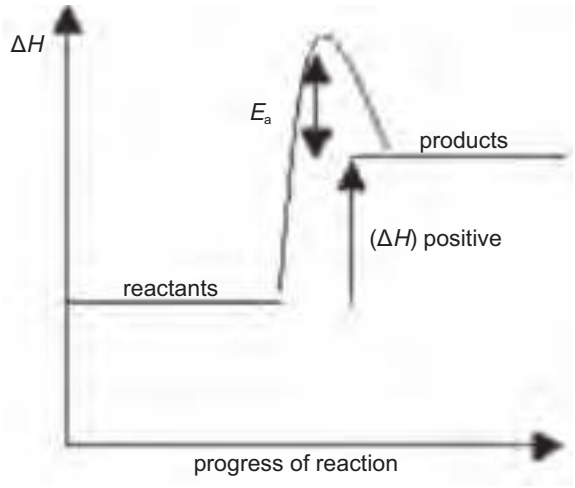
(iii) Single bonds: σ or 'sigma'
Additional bonds in multiple bonds: π or 'pi'
Both required for the mark. [1]

(iv) Dividing mass percentages by molar masses (1)
C: 41.3 / 12.0 = 3.44
H: 10.3 / 1.0 = 10.3
Si: 48.4 / 28.1 = 1.72
Correct empirical formula = C_2H_6Si(1)
Possible structure must contain a Si=Si bond, with each silicon bonded to hydrogens or alkyl groups that satisfy the molecular formula of $C_4H_{12}Si_2$.(1) [3]

[Total: 17]

2 (a) (i) $MgCO_3 \rightarrow MgO + CO_2$ (ignore state symbols) [1]

(ii) Products drawn at a higher energy than reactants. (1)
Enthalpy change of reaction arrow pointing *from* reactant energy level *to* product energy level. (1)
Activation energy shown as between the reactant energy level and the top of the energy 'hill'. (1)



[3]

(b) Trend: decomposition temperature increases. (1)

Explanation: charge density of metal cation decreases down the group. (1)
Metal cation becomes less polarising down the group. (1)
Smaller bond weakening effect on carbonate / carbonate ion more stable / more energy required to decompose carbonate. (1)

ALTERNATIVE EXPLANATION:

Lattice energy of the carbonates down a group becomes less exothermic… (1)
at a slower rate than the oxides… (1)
So $\Delta_r H^{\ominus}$ becomes more endothermic (and decomposition temperature increases). (1) [4]

(c) (i) $x = 4$ [1]

(ii) $MgCO_3$ (accept formula or name) [1]

(iii) Acid-base [1]

(d) (i) 2+ OR +2 but not just '2' [1]

(ii) Amount of excess H^+ in conical flask
$= 41.60\,cm^3 \times 0.100\,mol\,dm^{-3} = 0.00416\,mol$ (1)
Amount of excess H^+ in $100\,cm^3$ volumetric flask
$= 10 \times 0.00416\,mol = 0.0416\,mol$ (1)
Final answer given to 3 significant figures. (1) [3]

(iii) Initial amount of H^+
= $30.0\,cm^3 \times 5.00\,mol\,dm^{-3} = 0.150\,mol$ (1)
Amount of H^+ that reacted with the sample of dolomite
= $0.150\,mol - 0.0416\,mol = 0.108\,mol$ (1) [2]

(iv) Amount of carbonate reacted
= ½ × 0.108 mol = 0.054 mol (1)
Mass of carbonate reacted
= $0.054\,mol \times 60\,g\,mol^{-1} = 3.25\,g$ (1) [2]

(v) Mass of calcium
= ½ × 0.054 mol × $40.1\,g\,mol^{-1} = 1.09\,g$ (1)
Mass of *Z* = 5.00 g − 3.25 g − 1.09 g = 0.66 g (1)
Molar mass of *Z*
= 0.66 g / (½ × 0.054 mol) = $24\,g\,mol^{-1}$ (1)

Award full marks for alternative legitimate methods, for example:

Mass of Ca & *Z* = 5.00 g – 3.25 g = 1.75 g (1)
Amount of Ca*Z* = 1.75 g / (40.1 + M_Z) g mol^{-1} = 0.027 mol (1)
∴ $M_Z = 24\,g\,mol^{-1}$ (1)

Allow ecf from earlier parts. [3]

[Total: 22]

3 (a) (i) VSEPR or Valence Shell Electron Pair Repulsion (theory) [1]

(ii) Shape is trigonal planar (1)
BF_3. Bond angle = 120° (1) [2]

(b) (i) The number of valence or outer-shell electrons (on the central atom) exceeds 8.
OR octet is expanded. [1]

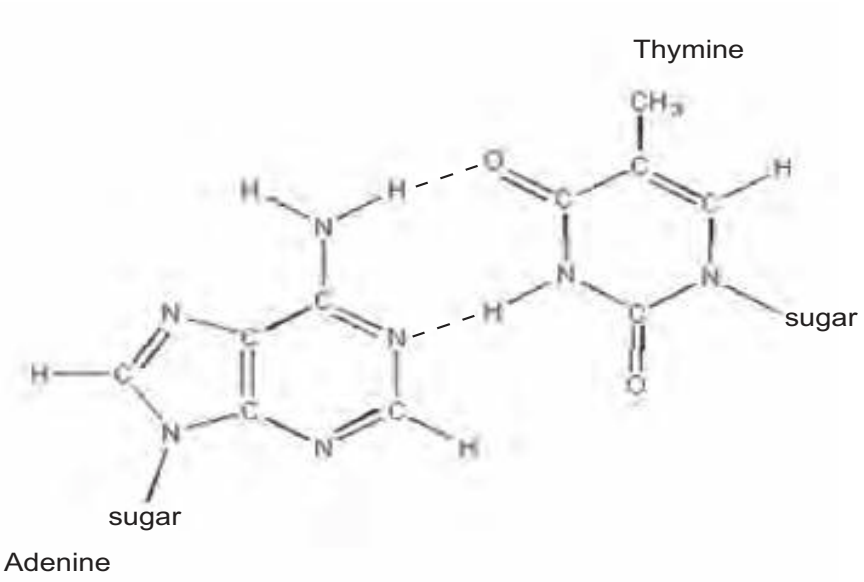
(ii) Structure named as pentagonal bipyramidal. (1)
Bond angles of 72° (ignore multiples of 72°) (1)
and 90° (ignore 180°). (1) [3]

(iii) There isn't space around the bromine atom for seven bonds to fluorine atoms / steric hindrance / bromine atom is too small.
Allow suggestions that fluorine isn't oxidising enough
OR the 6th and 7th ionisation energies of bromine are too high
OR it would spontaneously dissociate to give BrF_5 and F_2. [1]

(c) (i) (Trigonal) pyramidal [1]

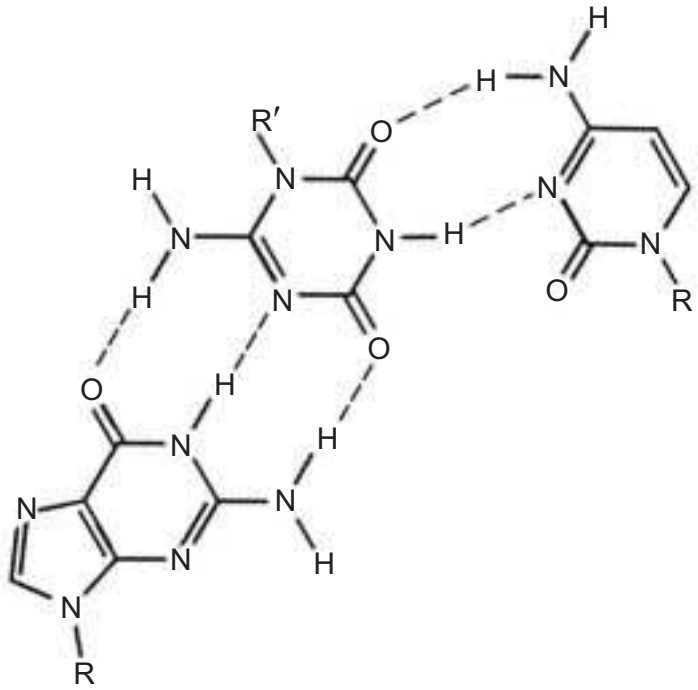
(ii) 4 bonding pairs (1)
2 lone pairs (1) [2]

(d) (i) Line connecting NH hydrogen on adenine and upper O on thymine (1)
Line connecting adenine right-hand heterocyclic N and NH hydrogen on thymine. (1)



[2]

(ii) Janus wedge between the two bases with a valid H-bond connecting the wedge to each base. (1)
All correct H-bonds shown between Janus wedge and cytosine. (1)
All correct H-bonds between Janus wedge and guanine. (1)

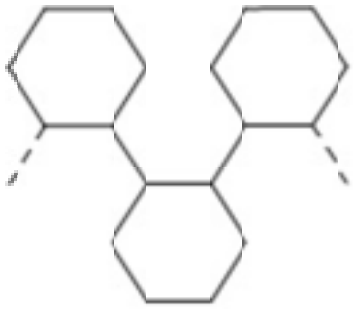


[3]

[Total: 16]

4 (a) (i) Addition [1]

(ii) Three monomer units lacking a double bond joined together correctly as shown (conformation not important). (1)
Drawn between brackets with bond sticking through, or with dotted bonds at the ends. (1)



[2]

(iii) 2500 / 82 = 30 units (1)
Denominator must be 82, not 84.
Answer must be an integer. [1]

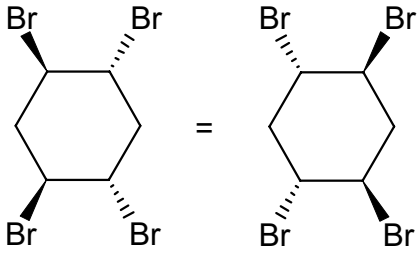
(b) (i) $C_6H_{10} + Br_2 \rightarrow C_6H_{10}Br_2$
Ignore state symbols. [1]

(ii) Any unambiguous structure for 1, 2-dibromocyclohexane.
Ignore any stereochemistry. [1]

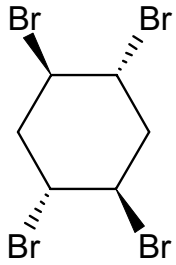
(iii) 1, 2-dibromocyclohexane [1]

(c) 1, 3-dibromocyclohexane (1)
1, 4-dibromocyclohexane (1)
Credit any unambiguous structure. Ignore any stereochemistry. [2]

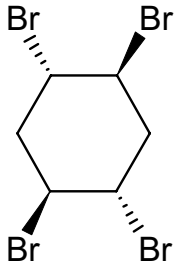
(d) Correct use of hashed and wedged bonds to show:
1R, 2R, 4S, 5S-tetrabromocyclohexane, which is the same as 1S, 2S, 4R, 5R-tetrabromocyclohexane (1)



1R,2R,4R,5R-tetrabromocyclohexane (1)



1S,2S,4S,5S-tetrabromocyclohexane (1)



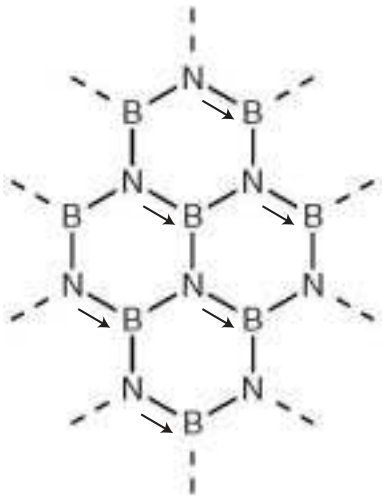
The first mark only awarded if just one of the two structures is given (since they are the same) or if two given structures are identified as identical. [3]

(e) (i) **X** = Br_2 [1]

(ii) **Y** = H_2 [1]

(iii) No. moles of X = 1 (1)
No. moles of Y = 4 (1) [2]

(iv) Each dative bond drawn from N to B. (1)
Each B receiving one dative bond and each N giving one.(1)
Allow bonds without arrows only if they are accompanied with a positive charge on the N and a negative charge on the B.



[2]

(v) Diamond (or silicon or germanium or zinc blende) [1]

[Total: 19]

5 (a) (i) Perform the experiment in a fume cupboard (to limit exposure to toxic iodoethane) (1)
Use a heating mantle rather than a Bunsen burner (to reduce risk of flammable vapours catching fire)
OR avoid (naked) flames (1) [2]

(ii) To exclude any trace of water / moisture OR chemically dry [1]

(b) (i) Amount of Mg = 1.5 g / 24.3 g mol^{-1} = 0.0617 mol [1]

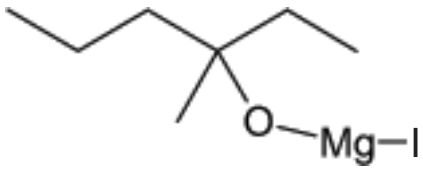
(ii) Mass of C_2H_5I = 0.0617 mol × 156 g mol^{-1} = 9.63 g (1)
Volume of C_2H_5I = 9.63 g / 1.93 g cm^{-3} = 5.0 cm^3 (1) [2]

(iii) Solvent [1]

(c) (i) High activation energy for the reaction (1)
due to the breaking of (strong) covalent or C-I bonds (1)
Reaction is slow (1) Max. 2 [2]

(ii) C_2H_5MgI [1]

(d) (i) Allow any unambiguous structure corresponding to:



[1]

(ii) Amount of pentan-2-one
= 6.0 cm^3 × 0.814 g cm^{-3} / 86 g mol^{-1} = 0.0568 mol (1)
More moles of magnesium / Grignard than pentan-2-one (1) [2]

(e) (i) 3-methylhexan-3-ol structure
Allow any unambiguous structure
Accept ecf from **(d) (i)** [1]

(ii) Ethane [1]

(iii) To slow down (an otherwise vigorous) reaction
OR the hydrolysis / reaction is exothermic
OR to stop boiling or spitting [1]

(f) (i) Ethoxyethane has low solubility in water (1)
Ethoxyethane is less dense than water (1) [2]

(ii) To extract the product / alcohol which has dissolved in the water (it is more soluble in the ether) [1]

(g) 1 (Magnesium) salts or $MgCl_2$ or MgI_2 (1)
2 Acid or HCl (1)
3 Iodine (1)
4 Water (1) [4]

(h) To dry the ethoxyethane / absorb water / dehydrating agent [1]

(i) Filter or decant (but not the distillate) (1)
Distil, collecting the fraction at or close to 143 °C (1)
Ignore reference to different temperatures / products.
Product alcohol has to be distilled *off* / *over*. [2]

[Total: 26]