MEGA LECTURE

A-LEVEL AP1 PAPER 1 MS

1. (a) (Enthalpy change to) break the bond in 1 mol of chlorine (molecules)

Allow (enthalpy change to) convert 1 mol of chlorine molecules into atoms
Do not allow energy or heat instead of enthalpy, allow heat energy

1

To form (2 mol of) gaseous chlorine atoms / free radicals

Can score 2 marks for 'Enthalpy change for the reaction':
$Cl_2(g)$ $2Cl(g)$
Equation alone gains M2 only
Can only score M2 if 1 mol of chorine molecules used in M1 (otherwise it would be confused with atomisation enthalpy)
Any mention of ions, CE = 0

1

(b) (For atomisation) only 1 mol of chlorine atoms, not 2 mol (as in bond enthalpy) is formed / equation showing ½ mol chlorine giving 1 mol of atoms

Allow breaking of one bond gives two atoms
Allow the idea that atomisation involves formation of 1 mol of atoms not 2 mol
Allow the idea that atomisation of chlorine involves half the amount of molecules of chlorine as does dissociation
Any mention of ions, CE = 0

1

(c) (i) $\frac{1}{2}F_2(g) + \frac{1}{2}Cl_2(g) \rightarrow ClF(g)$

1

(ii) $\Delta H = \frac{1}{2}E(F–F) + \frac{1}{2}E(Cl–Cl) – E(Cl–F)$

Allow correct cycle

1

E(Cl–F) = ½E(F–F) + ½E(Cl–Cl) ΔH
= 79 + 121 (56)
= 256 (kJ mol^{-1})

256 scores zero
Ignore units even if wrong

1

(iii) $\frac{1}{2}Cl_2 + 3/2\ F_2 \rightarrow ClF_3$

If equation is doubled CE=0 unless correcr answer gained by / 2 at end
This would score M1

1

$\Delta H = \frac{1}{2}E(Cl–Cl) + 3/2\ E(F–F) – 3E(Cl–F)$
= 121 + 237 768 / (or 3 × value from (c)(ii))

This also scores M1 (note = 358 768)

1

= 410 (kJ mol $^{-1}$)

If given value of 223 used ans = 311

Allow 1 / 3 for +410 and +311

1

(iv) (Bond enthalpy of) Cl F bond in ClF is different from that in ClF_3

Allow Cl-F bond (enthalpy) is different in different compounds (QoL)

1

(d) NaCl is ionic / not covalent

1

[11]

2. (a) (i) ΔH = Σ bonds broken –Σ bonds formed

1

= 944/2 + 3/2 × 436 –3 × 388

1

= –38 (kJ mol^{-1})

ignore units even if incorrect

correct answer scores 3

–76 scores 2/3

+38 scores 1/3

1

(ii) mean / average bond enthalpies are from a range of compounds
or
mean / average bond enthalpies differ from those in a single compound / ammonia

1

(b) ΔS = Σ*S* products –Σ *S* reactants

1

= 193 – (192/2 + 131 × 3/2)

1

= –99.5 J K^{-1} mol^{-1}

units essential for M3

correct answer with units scores 3

–199 J K^{-1} mol^{-1} & –99.5 score 2/3

–199 and + 99.5 J K^{-1} mol^{-1} score 1/3

1

(c) (i) $\Delta G = \Delta H - T\Delta S$ = –46 + 800 × 99.5/1000

mark is for putting in numbers with 1000

if factor of 1000 used incorrectly CE = 0

1

= 33.6 or 33600

allow 33 to 34 (or 33000 to 34000)

1

kJ mol^{-1} with J mol^{-1}

correct units for answer essential

if answer to part (b) is wrong or if -112 used, mark consequentially e.g.

- *–199 gives 113 to 114 kJ mol^{-1} (scores 3/3)*
- *–112 gives 43 to 44 kJ mol^{-1} (scores 3/3)*

1

(ii) If answer to (c) (i) is positive: not feasible / not spontaneous

If answer to (c) (i) is negative: feasible / spontaneous

if no answer to (c) (i) award zero marks

1

[11]

3. (a) (i) *Moles of PCl_3*: 0.345 – 0.166 = 0.179 **(1)**
Moles of Cl_2: 0.268 – 0.166 = 0.102 **(1)**
3 sig figs

(ii) 0.447 **(1)**
allow 2 sig figs
conseq on (i)

3

(b) *Mole fraction of PCl_3*: 0.179/0.447 **(1)** = 0.4(00)
Partial pressure of PCl_3: pp = mol f^n × total P **(1)**
= 0.400 × 225 = 90 **(1)** kPa **(1)**

3

(c) (i) $K_p = \frac{P_{PCl_3}}{P_{PCl_5} \times P_{Cl_2}}$ **(1)**
ignore brackets except [ ]
must show P

(ii) $K_p = \frac{83.6}{90.1 \times 51.3}$ **(1)** = 1.8**(1)** × 10^{-2} **(1)** Kpa^{-1} **(1)** (or 1.81 × 10^{-5} Pa^{-1})
If 83.6 and 51.3 wrong way round, AE – 1, answer = 6.81 × 10^{-3}
If K_p × in (i) allow max 2 for substitution of numbers and conseq units

4

(d) (i) increased **(1)**
(ii) increased **(1)**

2

[12]

4. (a) The enthalpy change / heat energy change / $\Delta\vec{H}$ for the formation of one mole of (chloride) ions from (chlorine) atoms

Allow enthalpy change for Cl + e Cl
Do not allow energy change
ionisation energy description is CE=0
Allow enthalpy change for the addition of 1 mol of electrons to Chlorine atoms
penalise Cl_2 and chlorine molecules CE = 0
allow chlorine ions

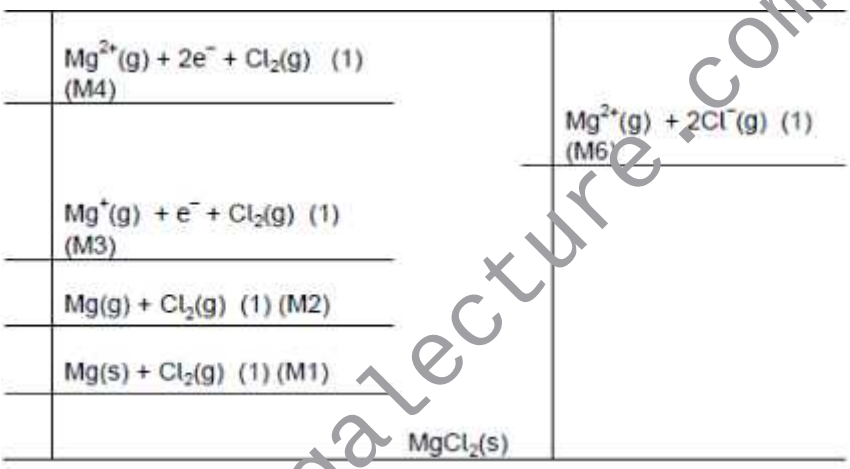
1

Atoms and ions in the gaseous state

Or state symbols in equation
Cannot score M2 unless M1 scored
except allow M2 if energy change rather than enthalpy change
ignore standard conditions

1

(b) $Mg^{2+}(g) + 2e + 2Cl(g)$ (1)
(M5)



Allow e for electrons (i.e. no charge)
State symbols essential
If no electrons allow M5 but not M3,M4
If incorrect 1 / 2 Cl_2 used allow M3 and M4 for correct electrons (scores 2 / 6)

6

(c) $\Delta H_f(MgCl_2) + \Delta H_a(Mg) + 1^{st}$ IE(Mg) + 2^{nd} IE(Mg) $+2\Delta H_a(Cl) = 2EA(Cl) + LE(MgCl_2)$

Allow Enthalpy of Formation = sum of other enthalpy changes (incl lattice formation)

1

$2EA(Cl) = 642 + 150 + 736 + 1450 + 242 - 2493 = 727$

1

$EA(Cl) = 364$ (kJ mol $^{-1}$)

Allow 363 to 364
Allow M1 and M2 for 727
Allow 1 (1 out of 3) for +364 or +363 but award 2 if due to arithmetic error after correct M2
Also allow 1 for 303
Units not essential but penalise incorrect units
Look for a transcription error and mark as AE

1

1

(d) (i) Magnesium (ion) is smaller **and** more charged (than the sodium ion)
OR
magnesium (ion) has higher charge to size ratio / charge density

Do not allow wrong charge on ion if given
Do not allow similar size for M1
Do not allow mass / charge ratio

1

(magnesium ion) attracts water more strongly

Mark independently
Mention of intermolecular forces, (magnesium) atoms or atomic radius CE = 0

1

(ii) Enthalpy change = LE($MgCl_2$) + Σ(ΔH_{hyd}ions)
= 2493 + (1920 + 2 × 364)

1

= 155 (kJ mol $^{-1}$)

Units not essential but penalise incorrect units

→

1

[15]

5. (a) $KNO_3(s)$ $K^+(aq) + NO_3^-(aq)$

do not allow equations with H_2O
allow aq and the word 'water' in equation

1

(b) increase in disorder because solid solution / increase in number of particles / 1 mol (solid) gives 2 mol (ions/particles) / particles are more mobile

allow random or chaos instead of disorder
penalise if molecules/atoms stated instead of ions
allow any reference to increase in number of particles even if number of particles wrong

1

(c) $\Delta G = \Delta H - T\Delta S$ / $T = \Delta H/\Delta S$

1

$T = \Delta H/\Delta S = (34.9 \times 1000)/117$

also scores M1

1

= 298 K

correct answer scores 3, units essential
0.298 scores M1 only

1

(d) (i) positive / increases / $\Delta G > 0$

Allow more positive

1

(ii) if ans to (d) (i) positive, dissolving is no longer spontaneous / no longer feasible / potassium nitrate does not dissolve / less soluble

if ans to (d) (i) negative, dissolving is spontaneous / feasible / potassium nitrate dissolves / more soluble

If no mention of change to ΔG in (d)(i), Mark = 0 for (d)(ii)

1

[7]

6. (a) (i) Δ*H* = Σ(enthalpies formation products) Σ(enthalpies formation reactants)

Or correct cycle with enthalpy changes labelled

1

= 111 (75 242)

1

= (+)206 (kJ mol 1)

206 scores 1 only

Units not essential if ans in kJ mol 1 but penalise incorrect units

1

(ii) Δ*S* = Σ(entropies of products) Σ(entropies reactants)

= 198 + 3 × 131 (186 + 189)

1

= (+) 216 (J K 1 mol 1)

OR

0.216 kJ K 1 mol 1

Units not essential but penalise incorrect units

1

(b) When $\Delta G = 0$ OR $\Delta H = T\Delta S$ **1**

$T = \Delta H / \Delta S$

M2 also scores M1

= 206 × 1000 / 216 **1**

Allow error carried forward from (a)(i) and (a)(ii)
Ignore unexplained change of sign from − to +

= 954 K **1**

Allow 953 − 955, Units of K essential, must be +ve
If values from (a)(i) and (a)(ii) lead to negative value in M3 allow M1 to M3 but do not allow negative temperature for M4
If negative value changed to positive for M4, allow M4

(c) To speed up the rate of reaction OR wtte **1**

Allow so that more molecules have energy greater than the activation energy
IF T in (b) > 1300 allow answers such as;
to reduce energy cost
to slow down reaction
do NOT allow to increase rate

(d) (i) **Method 1**

$\Delta G = \Delta H - T\Delta S$

$\Delta G = 41 - (1300 \times 42 / 1000)$ (M1) **1**

If 42 and not 42 / 1000 used can score M3 only but allow $\Delta G = 41 \times 1000 - (1300 \times 42)$ (M1)

= +13.6 kJ mol^{-1} **1**

=13600 J mol^{-1} (M2)
Units essential

ΔG must be negative for the reaction to be feasible. **1**
OR ΔG is positive so reaction is not feasible

Method 2

For reaction to be feasible ΔG must be negative or zero **1**

T when $\Delta G = 0 = \Delta H / \Delta S = 976K$ **1**

ΔS is −ve so ΔG must be +ve at temperatures above 976K / at 1300 *K* **1**

(ii) If the temperature is lowered **1**
(Ignore reference to catalyst and / or pressure)

Alternative mark scheme (if T is calculated)
Allow T reduced to 976 K or lower M1

–

1

ΔG will become (more) negative because
the TΔS term will be less positive / TΔS>ΔH
At this temperature (the reaction becomes feasible because) ΔG < = 0 M2

1

[15]

7. (a) Standard pressure (100 kPa) (and a stated temperature)

Allow standard conditions. Do not allow standard states
Allow any temperature
Allow 1 bar but not 1atm
Apply list principle if extra wrong conditions given
Penalise reference to concentrations

1

(b) Hydrogen bonds between water molecules

1

Energy must be supplied in order to break (or loosen) them

Allow M2 if intermolecular forces mentioned
Otherwise cannot score M2
Δ Δ CE = 0/2 if covalent or ionic bonds broken

1

(c) *T = H/ S*

1

= (6.03 × 1000)/22.1

1

= 273 K

Allow 272 to 273; units K must be given
Allow 0°C if units given
0.273 (with or without units) scores 1/3 only
Must score M2 in order to score M3
Negative temperature can score M1 only

1

(d) The heat given out escapes

1

(e) (Red end of white) light (in visible spectrum) absorbed by ice

Allow complementary colour to blue absorbed

1

Blue light / observed light is reflected / transmitted / left

Penalise emission of blue light

1

[9]