MEGA LECTURE

TOPIC 10 HW MS

1. (a) Enthalpy change/heat energy change when one mole of gaseous atoms

Allow explanation with an equation that includes state symbols

1

Form (one mole of) gaseous negative ions (with a single charge)

If ionisation/ionisation energy implied, CE=0 for both marks
Ignore conditions

1

(b) Fluorine (atom) is smaller than chlorine/shielding is less/ outer electrons closer to nucleus

Fluorine molecules/ions/charge density CE=0 for both marks

1

(Bond pair of) electrons attracted more strongly to the nucleus/protons

1

(c) Fluoride (ions) smaller (than chloride) / have larger charge density

Any reference to electronegativity CE=0

1

So (negative charge) attracts (δ+ hydrogen on) water more strongly

Allow H on water, do not allow O on water
Allow F - hydrogen bonds to water, chloride ion does not
Δ *Mark independently*

1

(d) (i) *H*(solution) = LE + Σ(hydration enthalpies) / correct cycle

AgF_2 or other wrong formula CE = 0
Ignore state symbols in cycle

1

LE = -20 -(-464 + -506)

1

= (+) 950 kJ mol^{-1}

Ignore no units, penalise M3 for wrong units
-950 scores max 1 mark out of 3
990 loses M3 but M1 and M2 may be correct
808 is transfer error (AE) scores 2 marks
848 max 1 if M1 correct
1456 CE=0 (results from AgF_2)

1

(ii) There is an increase in the number of particles / more disorder / less order

Allow incorrect formulae and numbers provided number increases
Do not penalise reference to atoms/molecules
Ignore incorrect reference to liquid rather than solution

1

(iii) Entropy change is positive/entropy increases and enthalpy change negative/exothermic

1

So ΔG is (always) negative

1

[12]

2. (a) Because it is a gas compared with solid carbon

Mark independently

1

Nitrogen is more disordered/random/chaotic/free to move

1

(b) 0 K/–273 C/absolute zero

1

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

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

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

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

Ignore $\ominus$ *in* $\Delta G^{\ominus}$

1

(d) ΔG is less than or equal to zero (ΔG 0)

Allow ΔG *is less than zero* ($\Delta G < 0$)

Allow ΔG *is equal to zero* ($\Delta G = 0$)

Allow ΔG *is negative*

1

(e) When $\Delta G = 0$ $T = \underline{\Delta H/\Delta S}$

1

$\Delta H = +90.4$

Allow $\Delta H = +90$

1

$\Delta S = \Sigma S(\text{products}) - \Sigma S(\text{reactants})$

1

$\Delta S = 211.1 - 205.3/2 - 192.2/2 = \underline{12.35}$

1

$T = (90.4 \times 1000)/12.35 = 7320$ K/7319.8 K

Allow 7230 to 7350 K *(Note 7.32 K scores 4 marks)*

Units of temperature essential to score the mark

1

(f) Activation energy is high

Allow chemical explanation of activation energy

Allow needs route with lower activation energy

Allow catalyst lowers activation energy

1

(g) $\Delta H = 1.9$ (kJ mol^{-1})

1

$\Delta S = 2.4 - 5.7 = -3.3$ (J K^{-1} mol^{-1})

for M1 and M2 allow no units, penalise wrong units

1

ΔG is always positive

This mark can only be scored if ΔH is +ve and ΔS is –ve

1

[14]

3. (a) Enthalpy change for the formation of 1 mol of gaseous atoms
allow heat energy change for enthalpy change

1

From the element (in its standard state)
ignore reference to conditions

1

Enthalpy change to separate 1 mol of an ionic lattice/solid/compound
enthalpy change not required but penalise energy

1

Into (its component) gaseous ions
mark all points independently

1

(b) $\Delta H_L = -\Delta H_f + \Delta H_a$ + I.E. + 1/2E(Cl-Cl) + EA

Or correct Born-Haber cycle drawn out

1

= +411 + 109 + 494 + 121 – 364

1

= +771 (kJ mol^{-1})

–771 scores 2/3
+892 scores 1/3
–51 scores 1/3
–892 scores zero
+51 scores zero *ignore units*

1

(c) (i) Ions are perfect spheres (or point charges)

1

Only electrostatic attraction/no covalent interaction

mention of molecules/intermolecular forces/covalent bonds
CE = 0
allow ionic bonding only
If mention of atoms CE = 0 for M2

1

(ii) Ionic

Allow no covalent character/bonding

1

(iii) Ionic with additional covalent bonding

Or has covalent character/partially covalent
Allow mention of polarisation of ions or description of polarisation

1

[11]

4. (a) (i) (Enthalpy change for formation of) 1 mol (of CaF_2) from its ions

allow heat energy change
do not allow energy or wrong formula for CaF_2
penalise 1 mol of ions
CE=0 if atoms or elements or molecules mentioned
ignore conditions

1

ions in the gaseous state

ions can be mentioned in M1 to score in M2
allow fluorine ions
$Ca^{2+}(g) + 2F^-(g)$ CaF_2 scores M1 and M2

1

(ii) (enthalpy change when) 1 mol of gaseous (fluoride) ions (is converted) into aqueous ions / an aqueous solution

allow $F^-(g)$ $F^-(aq)$ (ignore + aq)
do not penalise energy instead of enthalpy
allow fluorine ions
do not allow F^- ions surrounded by water

1

(b) water is polar / H on water is $\delta+$ / is electron deficient / is unshielded **1**

penalise H^+ on water 1 mark

(F^- ions) attract water / $\delta+$ on H / hydrogen

allow H on water forms H-bonds with F^-
allow fluorine ions
penalise co-ordinate bonds for M2
penalise attraction to O for M2

1

(c) $\Delta H = -(-2611) - 1650 + 2x - 506$

ignore cycles
M1 is for numbers and signs correct in expression

1

$= -51$ (kJ mol^{-1})

correct answer scores 2
ignore units even if incorrect

1

[7]

5. $\Delta S = \Sigma S$ products $- \Sigma S$ reactants

1

$\Delta S = (259 + 187) - (201 + 161)$

1

$\Delta S = 84$ (JK^{-1} mol^{-1}) *(Ignore units)*

*Allow – 84 to score **(1)** mark*

1

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

1

$= -21.6 - 298 \times 84/1000$
$= -46.6$ kJ mol^{-1} or $-46\,600$ J mol^{-1}

1

*Allow **(2)** for – 46.6 without units*
(Mark ΔG consequentially to incorrect ΔS)
(e.g. $\Delta S = -84$ gives $\Delta G = +3.4$ kJ mol^{-1})

1

[6]

6. (a) $\Delta G = \Delta H \quad T\Delta S$

Or expression $\Delta H \quad T\Delta S$ must be evaluated

1

If ΔG / expression <=0 reaction is feasible

Or any explanation that this expression <=0
Do not allow just $\Delta G = 0$

1

(b) The molecules become more disordered / random when water changes from a liquid to a gas / evaporates

For M1 must refer to change in state AND increase in disorder

1

Therefore the entropy change is positive / Entropy increases

Only score M2 if M1 awarded

1

TΔS>ΔH

Allow M3 for T is large / high (provided M2 is scored)

1

ΔG<0

Mark M3, M4 independently

1

(c) (i) Condition is $T = \Delta H / \Delta S$

ΔS = 189 205 / 2 131 = 44.5; **1**

ΔH = 242 therefore T = (242 × 1000) / 44.5) **1**

= 5438 K (allow 5400 5500 K) **1**

Units essential (so 5438 alone scores 3 out of 4)
2719 K allow score of 2
5.4 (K) scores 2 for M1 and M2 only
1646 (K) scores 1 for M1 only

(ii) It would decompose into hydrogen and oxygen / its elements **1**

Can score this mark if mentioned in M2

Because ΔG for this reaction would be <= 0 **1**

Allow the reverse reaction / decomposition is feasible
Only score M2 if M1 awarded

(d) $\Delta H = T\Delta S$ **1**

Allow correct substituted values instead of symbols

ΔS = 70 189 = 119 JK $^{-1}$ mol $^{-1}$ **1**

ΔH = (119 × 373) / 1000 = 44.4 kJ (mol $^{-1}$) (allow 44 to 45) **1**

Allow 44000 to 45000 J (mol $^{-1}$)
Answer must have correct units of kJ or J

[15]

7. (a) *Standard enthalpy change, $\Delta H^{\ominus}$*: $\Delta H_R = \Sigma\Delta H_{fproducts} - \Sigma\Delta H_{freactants}$ **(1)**
or cycle

ΔH_R = (0 + [2 × –242]) – (4 × –92) **(1)**
= –484 + 368
= –116 (kJ mol^{-1})

Allow max 1 for +116

Standard entropy change, $\Delta S^{\ominus}$: $\Delta S = \Sigma\Delta H_{f\ products} - \Sigma\Delta H_{f\ reactants}$

ΔS = ([2 × 223] + [2 × 189]) - (205 + [4 × 187]) **(1)**
= 824 – 953
= –129 (J K^{-1} mol^{-1})

allow max one for +129

6

(b) (i) *Effect*: Equilibrium displaced to right / to products **(1)**
Explanation: Reaction is endothermic **(1)**
Constraint reduced **(1)**
mark separately

(ii) Feasible when $\Delta G \leq 0$ **(1)**

$\Delta G = \Delta H - T\Delta S$ **(1)**
$T = \Delta H/\Delta S = 208 \times 1000$ **(1)** / 253
= 822 K **(1)**

7

[13]

8. C

[1]

9. C

[1]