Gateways School

**Thermodynamics**

**Revision PPQ Answers**

45 marks

**Q1.**

(a)    Cl(g) + e- → Cl-(g)

*State symbols essential*

*Allow e with no charge*

*This and all subsequent equations must be balanced*

**1**

(b)    There is an attraction between the nucleus / protons and (the added) electron(s)

**1**

Energy is released (when the electron is gained)

*Allow product more stable / product has lower energy*

*Allow reaction exothermic / heat released*

*Allow reference to chlorine rather than fluorine*

*Wrong process eg ionisation, boiling CE = 0*

**1**

(c)    (i)      Top line: + e– + F(g)

*Penalise missing / wrong state symbols one mark only*

*Penalise Fl or Cl one mark only*

**1**

Second line from top : + e– +  F2(g)

*Mark independently*

*Allow e with no charge*

**1**

Bottom two lines: +F2(g)

*Penalise each lack of an electron in M1 and M2 each time*

**1**

(ii)      E(F–F) + 732 + 289 + +203 = 348 + 955

E(F–F) = 79

**1**

E(F–F) = 158 (kJ mol–1)

*Award one mark (M2) if M1 wrong but answer = M1 × 2*

*Ignore no units, penalise wrong units but allow kJ mol–*

*Any negative answer, CE = 0*

**1**

(d)     (i)      Experimental lattice enthalpy value allows for / includes covalent interaction / non–spherical ions / distorted ions / polarisation

OR AgF has covalent character

*Allow discussion of AgCl instead of AgF*

*CE = 0 for mention of molecules, atoms, macromolecular, mean bond enthalpy, intermolecular forces (imf), electronegativity*

**1**

Theoretical lattice enthalpy value assumes only ionic interaction / point charges / no covalent / perfect spheres / perfectly ionic

OR AgF is not perfectly ionic

**1**

(ii)     Chloride ion larger (than fluoride ion) / fluoride ion smaller (than chloride ion)

*Penalise chlorine ion once only*

*Allow Cl– and F– instead of names of ions*

*Allow chloride ion has smaller charge density / smaller charge to size ratio but penalise mass to charge ratio*

**1**

Attraction between Ag+ and Cl– weaker / attraction between Ag+ and F– stronger

*For M2 Cl- and F- can be implied from an answer to M1*

*Mark M1 and M2 independently provided no contradiction*

*CE = 0 for mention of chlorine not chloride ion, molecules, atoms, macromolecular, mean bond enthalpy, intermolecular forces (imf), electronegativity*

**1**

**[12]**

**Q2.**

(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’:  
Cl2(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)      ½F2(g) + ½Cl2(g) → ClF(g)

**1**

(ii)     Δ*H* = ½E(F–F) + ½ E(Cl−Cl) – E(Cl−F)

*Allow correct cycle*

**1**

E(Cl−F) = ½E(F–F) + ½E(Cl−Cl) − Δ*H*

= 79 + 121 − (−56)

= 256 (kJ mol−1)

*−256 scores zero*

*Ignore units even if wrong*

**1**

(iii)    ½Cl2 + 3/2 F2 → ClF3

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

**1**

Δ*H* = ½ 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 ClF3

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

**1**

(d)     NaCl is ionic / not covalent

**1**

**[11]**

**Q3.**

(a)     ∆*G* = ∆*H* - *T*∆*S*

*Ignore ө*

**1**

(b)     0.098            or                 98

*Allow 0.097 to 0.099/97 to 99*

*Allow 0.1 only if 0.098 shown in working*

**1**

kJ K–1 mol–1                      J K–1 mol–1

*Allow in any order*

*Unless slope is approx. 100(90-110) accept only kJ K–1 mol–1. If no slope value given, allow either units*

**1**

–∆S/∆S

**1**

(c)     ∆G becomes negative

*Mark independently unless ∆G +ve then CE = 0*

**1**

So reaction becomes spontaneous/feasible

*Or reaction can occur below this temperature*

*Or reaction is not feasible above this temperature*

**1**

(d)     Ammonia liquefies (so entropy data wrong/different)

*Allow any mention of change in state or implied change in state even if incorrect*

*eg freezing/boiling*

**1**

**[7]**

**Q4.**

(a)    Chloride (ions) are smaller (than bromide ions)

*Must state or imply ions.*

*Allow chloride has greater charge density (than bromide).*

*Penalise chlorine ions once only (max 2 / 3).*

**1**

So the force of attraction between chloride ions and water is stronger

*This can be implied from M1 and M3 but do not allow intermolecular forces.*

**1**

Chloride ions attract the δ+ on H of water / electron deficient H on water

*Allow attraction between ions and polar / dipole water.*

*Penalise H+ (ions) and mention of hydrogen bonding for* ***M3***

*Ignore any reference to electronegativity.*

*Note: If water not mentioned can score M1 only.*

**1**

(b)     Δ*H*solution = Δ*H*L + Δ*H*hyd K+ ions + Δ*H*hyd Br −  ions / = 670 − 322 − 335

*Allow ΔHsolution= ΔHL + ΣΔHhyd*

**1**

= (+)13 (kJ mol−1)

*Ignore units even if incorrect.*

*+13 scores M1 and M2*

*−13 scores 0*

*−16 scores M2 only (transcription error).*

**1**

(c)    (i)      The entropy change is positive / entropy increases

*ΔS is negative loses M1 and M3*

**1**

Because 1 mol (solid) → 2 mol (aqueous ions) / no of particles increases

*Allow the aqueous ions are more disordered (than the solid).*

*Mention of atoms / molecules loses M2*

**1**

Therefore *TΔS* > Δ*H*

**1**

(ii)     Amount of KCl = 5/Mr = 5/74.6 = 0.067(0) mol

*If moles of KCl not worked out can score M3, M4 only (answer to M4 likely to be 205.7 K)*

**1**

Heat absorbed = 17.2 × 0.0670 = 1.153 kJ

*Process mark for M1 × 17.2*

**1**

Heat absorbed = mass × sp ht × Δ*T*

(1.153 × 1000) = 20 × 4.18 × Δ*T*

*If calculation uses 25 g not 20, lose M3 only (M4 = 11.04, M5 = 287)*

**1**

Δ*T* = 1.153 × 1000 / (20 × 4.18) = 13.8 K

*If 1000 not used, can only score M1, M2, M3*

*M4 is for a correct ΔT*

*Note that 311.8 K scores 4 (M1, M2, M3, M4).*

**1**

*T* = 298 − 13.8 = 284(.2) K

*If final temperature is negative, M5 = 0*

*Allow no units for final temp, penalise wrong units.*

**1**

**[13]**

**Q5.**

D

**[1]**

**Q6.**

C

**[1]**