PART H (*Blocks 7 and 8*)

Q6.36 to Q6.42 In answering these questions, you will need to use the data on a metal X and its compounds given below. Any other information you need should be taken from the S342 *Data Book*.

(a) Thermodynamic data at 298.15 K

Substance	State	$\Delta H_f^\ominus$ / kJ mol^{-1}	$\Delta G_f^\ominus$ / kJ mol^{-1}	$S^\ominus$ / J K^{-1} mol^{-1}
X	s	0	0	64.2
X_2O	s	−178.7	−147.3	125.6

(b) At 298.15 K, the standard electrode potential of the (X^+|X) couple is as follows:

$X^+(aq) + e = X(s)$; $E^\ominus(X^+|X) = -0.34$ V

(c) At 298.15 K, the standard solubility product of the metal(I) sulfide, X_2S, is:

$K_{sp}^\ominus(X_2S) = 6.05 \times 10^{-21}$

Q6.36 With reference to the information provided, select from the key the *one* **correct** statement.

KEY for Q6.36

A The standard electrode potential of the (X^+|X) couple is defined to be the standard emf of the cell represented by the following cell diagram:

$X(s)|X^+(aq)||H^+(aq)|H_2(g),Pt$

B The value of $\Delta G_f^\ominus(X^+, aq)$ is related to the standard electrode potential of the (X^+|X) couple by the following expression:

$\Delta G_f^\ominus(X^+, aq) = -FE^\ominus(X^+|X)$

where F is the Faraday constant.

C The solubility, s, and standard solubility product, $K_{sp}^\ominus$, of X_2S are related by the following expression:

$s = (K_{sp}^\ominus)^{1/3}/\gamma_\pm$

where $\gamma_\pm$ is the mean ionic activity coefficient of X_2S.

D For the cell represented by the following cell diagram

$Ag(s)|AgCl(s)|Cl^-(aq)||X^+(aq)|X(s)$

the implied cell reaction is as follows:

$Ag(s) + Cl^-(aq) + X^+(aq) = AgCl(s) + X(s)$

Q6.37 What is the standard electrode potential at 298.15 K of the following couple? Select from the key the value that is closest to your answer.

$X_2S(s) + 2e = 2X(s) + S^{2-}(aq)$

KEY for Q6.37

A	−1.54 V	D	+0.26 V
B	−0.94 V	E	+0.86 V
C	−0.77 V	F	+1.28 V

Q6.38 This question is concerned with a hypothetical battery system for which the overall cell reaction can be written as follows:

$X_2O(s) + Zn(s) + H_2O(l) = 2X(s) + Zn(OH)_2(s)$ (6.14)

Given that the half-reaction at each electrode involves the transfer of *two* electrons, and assuming that $\Delta H_m^\ominus$ and $\Delta S_m^\ominus$ for reaction 6.14 do not vary with temperature, what is the standard emf of the cell at 80 °C (353.15 K)? Select from the key the value that is closest to your answer.

KEY for Q6.38

A	0.71 V	D	1.18 V
B	0.87 V	E	1.42 V
C	0.92 V	F	1.74 V

Q6.39 to Q6.42 These questions are concerned with the electrochemical cell represented by the following cell diagram:

$X(s)|X^+(aq)||Ni^{2+}(aq)|Ni(s)$ (6.15)

Only those species shown in the cell diagram take part in the cell reaction. Assume that steps have been taken to eliminate any liquid junction potentials.

Q6.39 Calculate the standard emf at 298.15 K of the cell represented by cell diagram 6.15. Select from the key the value that is closest to your answer.

KEY for Q6.39

A	+0.92 V	E	−0.10 V
B	+0.58 V	F	−0.44 V
C	+0.44 V	G	−0.58 V
D	+0.10 V	H	−0.92 V

Q6.40 The key lists statements about the cell represented by cell diagram 6.15, which is set up under *standard* conditions at 298.15 K. Select *three* **correct** statements from the key.

KEY for Q6.40

A The spontaneous cell reaction is as follows:

$Ni(s) + 2X^+(aq) = Ni^{2+}(aq) + 2X(s)$

B Under balanced (zero-current) conditions, the potential difference ($\Delta\phi$) across the metal–solution interface in the half-cell on the right-hand side of cell diagram 6.15 must be −0.24 V.

C Under balanced (zero-current) conditions, the nickel electrode will be the positive electrode.

D Under balanced (zero-current) conditions, the rates of the oxidation ($X(s) \rightarrow X^+(aq) + e$) and reduction ($X^+(aq) + e \rightarrow X(s)$) reactions at the metal X electrode will both be zero.

E When the cell is operating spontaneously, the metal X electrode will be the anode.

F If current is drawn from the cell, the only reaction occurring at the nickel (Ni) electrode will be the reduction of nickel ions ($Ni^{2+}(aq)$) to nickel metal.

G If current is drawn from the cell, the overpotential at the metal X electrode will be positive.