# Chemistry 2850 Test 2

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| Time: 50 min | Questions: 8 | Marks: 49 |

Aids permitted: calculator, one $8.5 \times 11$-inch formula sheet
Useful data is given on the reverse of this page.
Write all answers in the booklets provided.

1. Briefly describe the standard hydrogen electrode. [3 marks]

2. What does "salting in" mean? What theory studied in class predicts this effect? Explain briefly. [4 marks]

3. Many reactions involve water as a reactant or product. When treating such reactions, we generally ignore the activity of the water, i.e. set its value to unity. Why is it often reasonable to do this? [2 marks]

4. Suppose that we measured the equilibrium constant of a reaction as a function of temperature. Briefly describe the procedure you could use to obtain the enthalpy of reaction from these data. [3 marks]

5. There are some cases where simple solubility calculations for ionic compounds based on $K_{\text{sp}}$ give very bad answers, even when we properly account for the effects of nonideal behavior. Describe a possible chemical complication which might throw off a naïve calculation. What chemical principle is involved? [4 marks]

6. The entropy of liquid water at 25°C is $69.95\,\text{J}\,\text{K}^{-1}\text{mol}^{-1}$. The heat capacity of liquid water is $75.40\,\text{J}\,\text{K}^{-1}\text{mol}^{-1}$. The enthalpy of fusion (melting) of ice at 0°C is 6007 J/mol. What is the entropy of ice at 0°C? [6 marks]

7. (a) Assuming that $\Delta H^\circ$ and $\Delta S^\circ$ are constant, calculate the standard Gibbs energy change for the reaction of calcium oxide with carbon dioxide to form calcium carbonate at 5°C. [10 marks]

   (b) The partial pressure of carbon dioxide in air is about $4 \times 10^{-4}$ bar. If we keep a sample of calcium oxide in air at 5°C, will it spontaneously convert to calcium carbonate? [4 marks]

8. Nickel-cadmium (nicad) batteries are based on the following half-cell reactions:

$$\begin{aligned} \text{NiO(OH)}_{(s)} + \text{H}_2\text{O}_{(l)} + \text{e}^- &\rightarrow \text{Ni(OH)}_{2(s)} + \text{OH}^-_{(aq)} \\ \text{Cd}_{(s)} + 2\text{OH}^-_{(aq)} &\rightarrow \text{Cd(OH)}_{2(s)} + 2\text{e}^- \end{aligned}$$

   (a) The emf of a nicad cell is 1.4 V. The standard reduction potential of cadmium (II) hydroxide is -0.809 V. What is the standard reduction potential of NiO(OH)? [3 marks]

   (b) What is the standard free energy of formation of NiO(OH)? [10 marks]

**Useful data**

$F = 96\,485.3383\,\mathrm{C/mol}$

$R = 8.314\,472\,\mathrm{J\,K^{-1}mol^{-1}}$

To convert degrees Celsius to Kelvin, add 273.15.

**Standard thermodynamic data at 1 bar and 25°C**

| Species | $\frac{\Delta_f H^\circ}{\mathrm{kJ/mol}}$ | $\frac{\Delta_f G^\circ}{\mathrm{kJ/mol}}$ | $\frac{C_{P,m}}{\mathrm{J\,K^{-1}mol^{-1}}}$ |
|---|---|---|---|
| $CO_{2(g)}$ | −393.51 | −394.37 | 37.1 |
| $CaCO_{3(s)}$ | −1206.9 | −1128.8 | 81.9 |
| $CaO_{(s)}$ | −634.92 | −603.30 | 42.8 |
| $Cd(OH)_{2(s)}$ | | −469.8 | |
| $H_2O_{(l)}$ | −285.830 | −237.140 | 75.40 |
| $Ni(OH)_{2(s)}$ | | −444 | |