

Chemistry 1210 Spring 2003 Test 3

Thursday, March 27, 2003

Time: 1 hour 50 minutes

Name: _____

Student Number: _____

*This exam consists of **seven** pages of questions, a periodic table, and the formula sheet. Please ensure that you have a complete paper and, if you do not, obtain one from me **immediately**. Good luck!*

- 1) **[3 marks]** The value of K_f for $[\text{Al}(\text{C}_2\text{O}_4)_3]^{-3}$ is 2×10^{13} and the K_{sp} of AlPO_4 is 6.3×10^{-19} . How many grams of AlPO_4 (molar mass 121.9529 grams) may be dissolved in 0.50 litres of a solution that has $[\text{C}_2\text{O}_4^{2-}] = 1.50 \text{ M}$?

[Ans.: 0.3976]

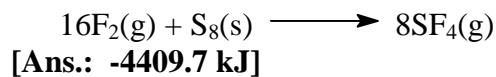
- 2) **[3 marks]** A balloon, initially at 2.0 litres, collapses to a volume of 0.5 litres and evolves 562 J of heat in the process. If the external pressure was 2.5 atmospheres for the collapse, calculate q , w , ΔE , and ΔH for the balloon.

[Ans.: $q = \Delta H = -562 \text{ J}$; $w = +380 \text{ J}$; $\Delta E = -182 \text{ J}$]

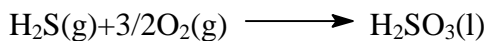
- 3) [3 marks] Given that ΔH_{sub} for $\text{S}_8(\text{s})$ (S_8 is a ring of singly bonded atoms) is 102.3 kJ, and the following bond energies:

| Bond | Bond Energy (kJ) |
|------|------------------|
| S-S | 268 |
| S-F | 287 |
| F-F | 158 |

estimate ΔH for the reaction:



- 4) [3 marks] Calculate ΔH for the reaction



given the following data and that fact that the naturally occurring form of sulphur is $\text{S}_8(\text{s})$:

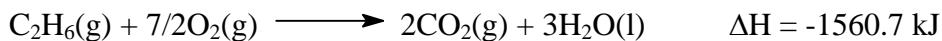


$$\Delta H^\circ_{\text{f}}(\text{SO}_2(\text{g})) = -445.5 \text{ kJ}$$



[Ans.: -771 kJ]

- 5) [4 marks] In one experiment, a 3.0069-gram sample of ethane (C₂H₆, molar mass 30.069 grams) was burned in a bomb calorimeter:



If the reaction took place at 25°C and the heat capacity of the bomb calorimeter was 2.70 kJ/°C, by how much did the temperature of the bomb calorimeter increase when the sample of ethane was burned?

[Ans.: 57.6°C]

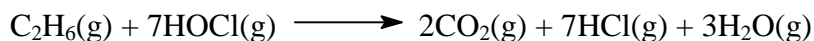
- 6) [3 marks] At 4.6 mmHg, the melting point of water is 0.01°C. Complete the following table for the conversion of ice to water at an external pressure of 4.6 mmHg. Indicate whether the values of ΔH , ΔS , and ΔG are positive (+), negative (-), or zero (0). *Note that for this question only, evaluation will be right minus wrong.* [Ans.: – in bottom right ΔG , rest +]

| T (°C) | ΔH | ΔS | ΔG |
|--------|------------------|------------------|------------------|
| -1 | | | |
| 0 | | | |
| +1 | | | |

7) [9 marks total] Given the following data, all for a temperature of 25°C:

| Compound | ΔG°_f (kJ) |
|-------------|-------------------------|
| $C_2H_6(g)$ | -32.82 |
| $HOCl(g)$ | -61.59 |
| $CO_2(g)$ | -394.4 |
| $H_2O(g)$ | -228.6 |
| $HCl(g)$ | -95.30 |

a) [1 mark] Calculate ΔG° for the reaction



at 25°C.

[Ans.: -1677.75 kJ]

b) [2 marks] Calculate ΔG for the reaction (at 25°C) if $P_{C_2H_6} = 0.01$ atm, $P_{HOCl} = 2.5 \times 10^{-4}$ atm, $P_{CO_2} = 3.0$ atm, $P_{HCl} = 5.5$ atm, and $P_{H_2O} = 0.001$ atm.

[Ans.: -1538.8 kJ]

c) [1 mark] Is the reaction spontaneous under either standard conditions or the conditions given in part (b)? How do you know?

[Ans.: ΔG and ΔG° are both < 0 , so rxn is spontaneous under both sets of conditions.]

d) [2 marks] What is ε° for the reaction at 25°C?

[Ans.: 1.242 V]

e) **[3 marks]** At 75°C , $\varepsilon^{\circ} = 1.25747 \text{ V}$. What are ΔH° and ΔS° for the reaction?
[Ans.: $\Delta H^{\circ} = -1553.5 \text{ kJ}$; $\Delta S^{\circ} = +416.7 \text{ J/K}$]

8) **[6 marks total]** The vapour pressure of $\text{CCl}_4(\text{l})$ is 120.9 mmHg at 299.46 K and 460.5 mmHg at 334.25 K.

a) **[1 mark]** What is the enthalpy of vaporization of $\text{CCl}_4(\text{l})$?
[Ans.: +31.99 kJ]

b) **[2 marks]** What is the normal boiling point of $\text{CCl}_4(\text{l})$?
[Ans.: 76.3°C]

c) **[1 mark]** What is the entropy of vaporization of $\text{CCl}_4(\text{l})$?
[Ans.: +91.5 J/K]

- d) [1 mark] Does the value predicted in (c) agree with what you'd predict using Trouton's Rule? Explain.

[Ans.: Yes]

- e) [1 mark] The value of S° for $\text{CCl}_4(\text{l})$ is 214.4 J/K . What is the value of S° for the gas?

[Ans.: 305.9 J/K]

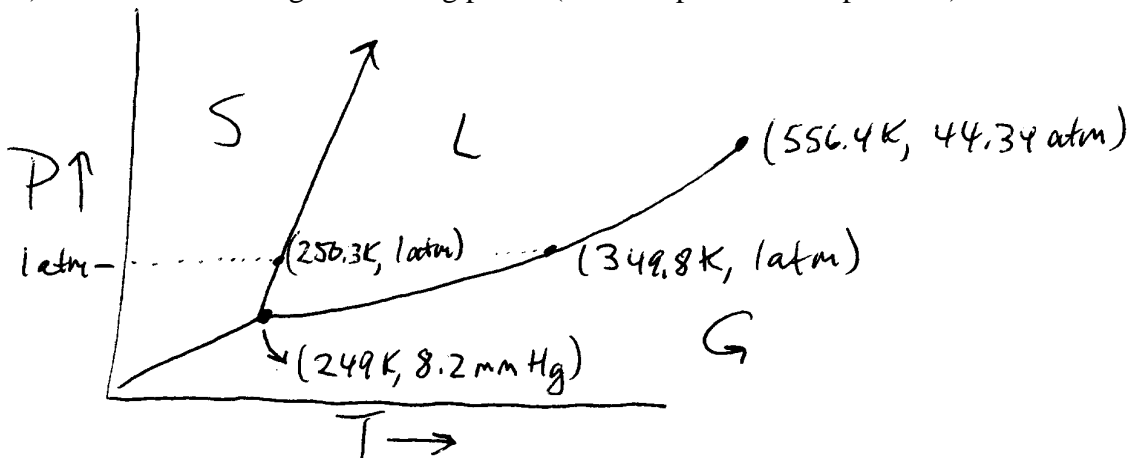
- 9) [5 marks total] Given the following data for carbon tetrachloride (CCl_4):

| Property | Value |
|---------------------|-----------|
| P_c | 44.34 atm |
| T_c | 556.4 K |
| P_{triple} | 8.2 mmHg |
| T_{triple} | 249 K |

and that the normal melting and boiling points of CCl_4 are 250.3 K, and 349.8 K respectively:

- a) [4 marks] Sketch the phase diagram for CCl_4 . On your diagram, label:

- The triple and critical points
- The parts of the graph where the solid, liquid, and gas are
- The normal melting and boiling points (both temperature and pressure)



- b) [1 mark] Which of the two phases (solid or liquid) is denser? How do you know?

[Ans.: solid]

10) **[5 marks total]** Iron crystallizes in a body-centred cubic unit cell and has a density = 7.874 g/cm^3 . What (in pm) are:

a) **[4 marks]** the length of the edge of the unit cell?

[Ans.: 286.7]

b) **[1 mark]** the radius of the iron atom?

[Ans.: 124.1]