

Chemistry 1210 Spring 2004 Test 3

Thursday, March 25, 2004

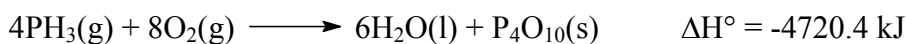
Time: 1 hour 50 minutes

Name: _____

Student Number: _____

*This exam consists of **nine** 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**. There are **46** regular marks and **four bonus question marks** available. Good luck!*

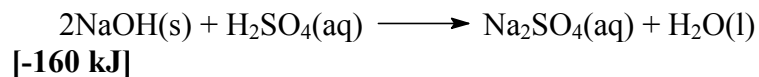
- 1) **[4 marks]** A 14.4959-gram sample of PH₃ (molar mass 33.99758 grams) was burned in a bomb calorimeter:



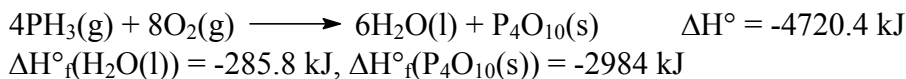
The temperature of the bomb calorimeter increased by 5.00°C. What was its heat capacity (in kJ/°C)? (Assume that the reaction took place at 25°C.)

[100.000 kJ/°C]

- 2) **[4 marks]** A 2.00-gram piece of NaOH (molar mass 40.00 grams) was placed in 100.0 mL of 0.25 M H₂SO₄ (D = 1.02 g/mL, S = 4.02 J/g-°C), initially at 21.2°C. The H₂SO₄ was contained in a cup with a heat capacity = 153.3 J/°C. If the final temperature of the system was 28.2°C, calculate ΔH° for the reaction



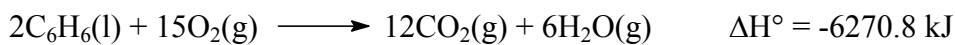
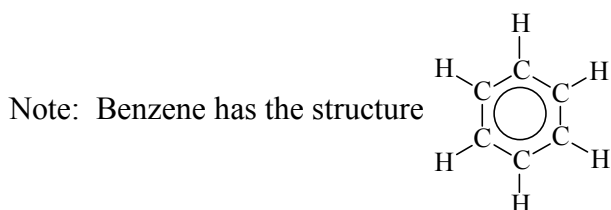
- 3) **[3 marks]** Given the following data:



Use **Hess' Law** to evaluate ΔH°_f(PH₃(g)). (Alternatively, for one of the three marks, you may use any other method you choose.)

[5.4 kJ]

- 4) [4 marks] The carbon-carbon bonds in benzene are all identical and, what's more, they're neither single nor double bonds but something in between. Use the data given below to estimate the carbon-carbon bond strength (in kJ/mol) in benzene.

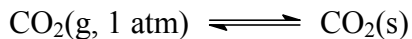


Bond	Bond Strength (kJ/mol)
C-H	414
C=O	799
O=O	498
O-H	464

$$\Delta\text{H}^\circ_{\text{vap}}(\text{C}_6\text{H}_6(\text{l})) = 32 \text{ kJ/mol}$$

[497.6 kJ/mol]

5) [3 marks] Given the following reaction:

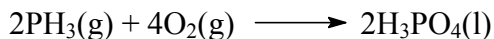


And that the normal sublimation point of CO_2 is -78.5°C , complete the following chart for the reaction above:

T($^\circ\text{C}$)	ΔH°	ΔS°	ΔG°
-50			
-75			
-100			

[All negative except ΔG° at -50 and -75 , which are positive]

6) [13 marks total] This question concerns the reaction



and uses the data (for a temperature of 25°C):

Compound	$\Delta\text{H}_f^\circ(\text{kJ})$	$\Delta\text{G}_f^\circ(\text{kJ})$	$\text{S}_f^\circ(\text{J/K})$
$\text{PH}_3(\text{g})$	5.4	13.4	210.2
$\text{H}_3\text{PO}_4(\text{l})$	-1277	-1019	
$\text{O}_2(\text{g})$			205.1

a) [3 marks] Calculate ΔH° , ΔS° , and ΔG° for a temperature of 25°C .
[-2564.8 kJ, -1.677 kJ/K, -2064.8 kJ]

b) [1 mark] What is $\text{S}^\circ(\text{H}_3\text{PO}_4(\text{l}))$?
[-218.1 J/K]

c) **[2 marks]** Assuming all conditions are held at standard, what voltage will a battery produce at 25°C if it is based on the reaction above?
[1.3375 v]

d) **[2 marks]** Calculate K_p for the reaction at 25°C.
[5.457 x 10³⁶¹]

e) **[2 marks]** Calculate ΔG for the reaction at 25°C if the $P_{\text{PH}_3} = 1 \times 10^{-6}$ atm and $P_{\text{O}_2} = 1 \times 10^{-12}$ atm.
[-1722.3 kJ]

f) **[3 marks]** At what temperature will the reaction become non-spontaneous if the $P_{\text{PH}_3} = 1 \times 10^{-6}$ atm and $P_{\text{O}_2} = 1 \times 10^{-12}$ atm?
[907.67 K or 634.52°C]

7) **[5 marks total]** Given the following data for carbon dioxide:

Critical point: 72.9 atm and 31°C

Triple point: 5.1 atm and -56.7°C

Normal sublimation point: -78.5°C

The solid is denser than the liquid

a) **[3 marks]** Sketch the phase diagram for CO₂. On your phase diagram, include:

- i) A proper title for your graph and proper labels and units for your axes
- ii) Which phases are present in which regions of your graph
- iii) A label for the triple point, the critical point, and the normal sublimation point

b) **[2 marks]** Estimate $\Delta H_{\text{sub}}^{\circ}$ for CO₂.
[26.18 kJ]

- 8) **[3 marks]** Lithium crystallizes in a body-centred cubic unit cell, has a density of 0.535 g/cm^3 , and has an atomic radius of 152 pm. ($1 \text{ pm} = 1 \times 10^{-12} \text{ m}$). Use these data to calculate the molar mass (in grams) of lithium.

[6.97]

- 9) **[4 marks]** When 6.0 moles of A ($P^* = 25 \text{ mmHg}$) are mixed with 4.0 moles of B ($P^* = 40 \text{ mmHg}$), the vapour pressure above the solution is observed to be 40 mmHg. From this information:

$$\Delta H_{\text{mix}} \quad 0 \quad <0 \quad >0$$

$$\Delta V_{\text{mix}} \quad 0 \quad >0 \quad <0$$

Deviations from Raoult's law? pos. no neg.

Azeotrope? max. no min.
boil boil

[>0, >0, pos., min. boil]

10) **[3 marks]** A 1.000-gram sample of the ionic solid M_3P caused the freezing point of 1.00 kg of water to be lowered by 0.0744°C . If the k_f for water is 1.86°C/molal , what is the metal, M ?

[Na]

BONUS QUESTION

[3 marks] The non-polar liquid cyclohexane has a vapour pressure of 101.6 mmHg at 25°C. What is its normal boiling point?

[81.7°C]