

Notre Dame University
Faculty of Natural & applied Sciences
Department of Sciences

Principles of Chemistry: CHM 211
Final Exam – Spring 2009
Duration: 120 minutes

22 → 31

23 → 32

Student Name: _____

I.D.#: _____

Please Encircle your section:

Sec.	Time	Instructor
A	MWF 9:00-10:00	Dr. M. HAROUN
B	MWF 1:00-2:00	Dr. M. HAROUN
C	TTH 8:00-9:30	Dr. M. BOULOS
D	TTH 11:00-12:30	Dr. C. TRATRAT
E	TTH 3:00-4:30	Dr. F. MOHASSEB
F	TTH 8:00-9:30	Dr. F. MOHASSEB

Please provide all your answers on the answer sheet only

Exam regulations:

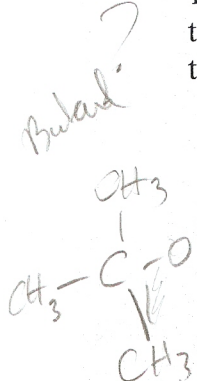
- Talking, improper seating, borrowing stationary items are not permitted.
- No questions will be allowed during the exam.
- In case of cheating the exam copies will be confiscated immediately and the student will have to leave the exam hall.
- Every proctor in the exam hall will exercise the right to keep and apply the regulations mentioned above.

Good Luck

Given data: R = Universal gas constant = 0.08206 L.atm/mol.K and 8.31 J/mol.K
 1 atm = 760 mmHg = 760 torr
 $\ln(P_1/P_2) = \Delta H/R (1/T_2 - 1/T_1)$
 Osmotic Pressure = MRT
 $P_{\text{solution}} = X_{\text{solvent}} P^{\circ}_{\text{solvent}}$

$\Delta T = mK$
 $P_{\text{freez}} - P_{\text{solid}}$

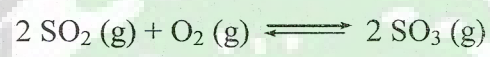
1] The freezing point of t-butanol is 25.50 °C and k_f is 9.1 °C.kg/mol. Usually t-butanol absorb water on exposure to air. If the freezing point of a 10.0-g sample of t-butanol is 24.59 °C, how many grams of water are present in the sample?



- a) 0.018
- b) 0.010
- c) 0.023
- d) 0.160
- e) 0.250

$25.5 - 24.59 = \frac{0 \text{ mmHg}}{10 \times 10^{-3}} \times 9.1$

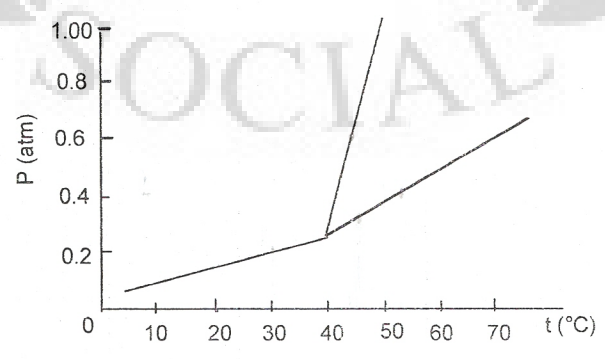
2] What is the equilibrium constant, at 25°C, for the equilibrium shown?
 $\Delta H^{\circ}_f(\text{SO}_2) = -294 \text{ kJ/mol}$, $\Delta H^{\circ}_f(\text{SO}_3) = -396 \text{ kJ/mol}$, $\Delta H^{\circ}_f(\text{O}_2) = 0 \text{ kJ/mol}$,
 $S^{\circ}(\text{SO}_2) = 248 \text{ J/K.mol}$, $S^{\circ}(\text{SO}_3) = 257 \text{ J/K.mol}$, $S^{\circ}(\text{O}_2) = 205 \text{ J/K.mol}$,



- a) 2.5×10^{31}
- b) 1.9×10^{29}
- c) 3.8×10^{-14}
- d) 1×10^{26}
- e) 2.5×10^{20}

$\Delta G = -RT \ln K$
 $\Delta G = \Delta H - T \Delta S$

3] At what temperature and pressure are only solid and vapor in equilibrium?



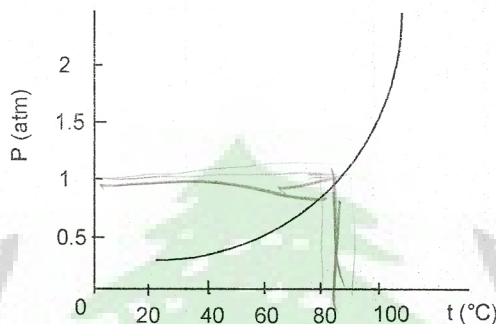
- a) 10°C, 0.45 atm
- b) 30°C, 0.20 atm
- c) 45°C, 0.30 atm
- d) 52°C, 0.40 atm
- e) 44°C, 0.60 atm

4] Which one of the following has the highest boiling point?

- a) pure water
- b) sugar: $C_6H_{12}O_6$ (0.01 M) in water
- c) NaCl (0.01 M) in water
- d) $CaCl_2$ (0.01 M) in water

$\Delta T = m \cdot K$
 $\Delta T = i \cdot m \cdot K$
 $\Delta T_{\text{boil}} = i \cdot m \cdot K$

5] What is the normal boiling point of the liquid that has the vapor pressure curve shown in the figure?



- a) 18°C
- b) 40°C
- c) 54°C
- d) 88°C
- e) 105°C

$M(\text{Fe}_2\text{O}_3) = 159.69 \text{ g/mol}$ $M(\text{Fe}) = 55.847 \text{ g/mol}$

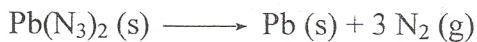
6] How much Fe can be produced if 100 g Fe_2O_3 and 100 g CO are mixed and react?



- a) 97 g
- b) 70 g
- c) 14 g
- d) 35 g
- e) 56 g

$100 \text{ g Fe}_2\text{O}_3 \cdot \frac{1 \text{ mol}}{159.69 \text{ g}} = 0.626 \text{ mol}$
 $100 \text{ g CO} \cdot \frac{1 \text{ mol}}{28.01 \text{ g}} = 3.57 \text{ mol}$
 $0.626 \text{ mol Fe}_2\text{O}_3 \cdot \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} = 1.252 \text{ mol Fe}$
 $1.252 \text{ mol Fe} \cdot 55.847 \text{ g/mol} = 70 \text{ g Fe}$

7] How many liters of N_2 (measured at STP) are produced by the reaction of 1.22 kg lead azide, $\text{Pb}(\text{N}_3)_2$?



- a) 93.8 L
- b) 325 L
- c) 282 L
- d) 31.3 L
- e) 129 L

1.22 kg Pb

$1.22 \text{ kg Pb} \cdot \frac{1 \text{ mol}}{207.2 \text{ g}} = 5.89 \text{ mol Pb}$
 $5.89 \text{ mol Pb} \cdot \frac{3 \text{ mol N}_2}{1 \text{ mol Pb}} = 17.67 \text{ mol N}_2$
 $17.67 \text{ mol N}_2 \cdot 22.4 \text{ L/mol} = 395.8 \text{ L}$

ans $\rightarrow 282 \text{ L}$

8] Given the reaction enthalpies

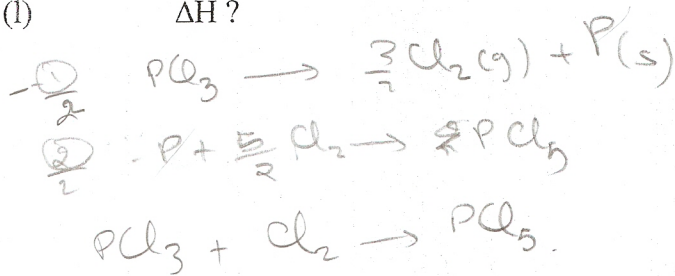


What is the reaction enthalpy for the following reaction



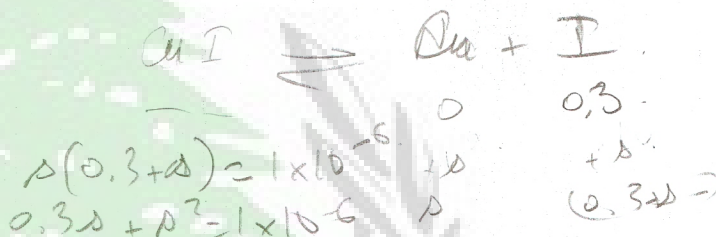
- a) 156.5 kJ
- b) -313 kJ
- c) 313 kJ
- d) -276 kJ
- e) -156.5 kJ

$= \frac{\Delta H_1}{2} + \frac{\Delta H_2}{2}$

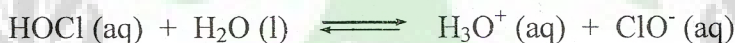


9] What is the solubility of CuI in 0.3 M NaI? $K_{sp}(CuI) = 1 \times 10^{-6}$

- a) 3.3×10^{-6}
- b) 2.4×10^{-7}
- c) 2.0×10^{-3}
- d) 1.0×10^{-6}
- e) 8.7×10^{-5}



10] Hypochlorous acid ionizes by the following equation:



What is the pH of a solution that is 0.55 M in hypochlorous acid (HOCl) and 0.35 M in potassium hypochlorite (NaOCl)? $pK_a(HOCl) = 7.53$

- a) 7.91
- b) 7.33
- c) 7.66
- d) 7.20
- e) 7.72

Handwritten work for Q10:
 $\frac{x(0.35+x)}{0.55} = 10^{-7.53}$
 $2.0193 \times 10^{-8} = \frac{0.35x + x^2}{0.55}$
 $0.35x + x^2 = 1.11 \times 10^{-8}$

11] The vapor pressure of the liquid is measured at two different temperatures with the following results: $T = 75^\circ C$, vapor pressure = 65.2 Torr and $T = 105^\circ C$, vapor pressure = 105 Torr. What is the enthalpy of vaporization of the liquid?

- a) 17.6 kJ
- b) 14.8 kJ
- c) 24.2 kJ
- d) 19.0 kJ
- e) 29.4 kJ

Handwritten work for Q11:
 $\ln \frac{P_1}{P_2} = \frac{\Delta H}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$
 $\ln \left(\frac{65.2/760}{105/760} \right) = \frac{\Delta H}{8.31} \left(\frac{1}{298} - \frac{1}{328} \right)$
 $\Delta H = 29.4 \text{ kJ}$

12] A 0.8135 g sample of a compound containing only carbon, hydrogen and oxygen produces 2.104 g CO₂ and 0.4306 g H₂O in a combustion analysis. What is empirical formula of the compound?

- a) CHO
- b) C₂H₂O
- c) CHO₂
- d) C₃H₃O₃
- e) C₄H₄O

Handwritten notes for Q12:
 $CO_2 \rightarrow C + 2O$
 $2.104g \rightarrow 44 \rightarrow 0.6, 0478 \text{ mole}$
 $0.5236g \rightarrow 20\% C \rightarrow 5.875$
 $H_2O \rightarrow 2H + O$
 $0.4306g \rightarrow 18 \rightarrow 2 \cdot 0.0478g$
 $10.0239 \text{ mol} \rightarrow 5.875\%$
 23.6%
 $156g$
 C_4H_4O

13] How much heat is required to increase the temperature of 2 moles of benzene (C₆H₆) from 10°C to 25°C? The specific heat capacity of benzene is 1.05 J/g.°C.

- a) 8.15 kJ
- b) 2.45 kJ
- c) 1.23 kJ
- d) 4.91 kJ
- e) 3.68 kJ

Handwritten notes for Q13:
 $C_s = \frac{E}{\Delta T \cdot m}$
 $1.05 = \frac{E}{15 \times 156}$

14] The addition of a nonvolatile solute to a liquid results in :

- a) the boiling point is increased, the freezing point is increased
- b) the boiling point is decreased, the freezing point is decreased
- c) the boiling point is decreased, the freezing point is increased
- d) the boiling point is increased, the freezing point is decreased

15] A solution is prepared by adding 20 g of a substance to 125 g of water at 25 °C. At this temperature, pure water has a vapor pressure of 23.76 Torr. What is the molar mass of the substance if the observed vapor pressure of the solution is 22.67 Torr?

- a) 32.4 g/mole
- b) 101.5 g/mole
- c) 86.3 g/mole
- d) 60.6 g/mole
- e) 123.8 g/mole

Handwritten notes for Q15:
 $P_{\text{pure water}} = 23.76 \text{ Torr}$
 $P_{\text{solution}} = 22.67$
 $X = \frac{22.67}{23.76} = 0.954$
 $\frac{6.944}{6.944 + \frac{20}{M}} = 0.954$
 59.46 g/mole

16] A gas mixture contains 7 g of N₂, 3 g of H₂, 16 g of O₂ and 16 g of CH₄ in a 1 L vessel at 0°C. Calculate the partial pressure of N₂ (in atm).

- a) 11.2
- b) 33.6
- c) 5.6
- d) 22.4
- e) 9.5

Handwritten notes for Q16:

N ₂	H ₂
7g	3g

 $P_i = \frac{nRT}{V} = \frac{3.25 \times 0.08206}{1} = 22.8$

Handwritten notes for Q16 (continued):
 $P_i = X_i P_t$
 $P_{N_2} = \frac{7/28}{7/28 + 3/2 + 16/32 + 16/16} \times P_t$
 $m_t = 3.25$
 $= 0.0769 \times P_t$

17] For the reaction : $2 \text{Cl}_2 (\text{g}) + 2 \text{H}_2\text{O} (\text{g}) \rightleftharpoons 4 \text{HCl} (\text{g}) + \text{O}_2 (\text{g})$ at 600°C , $K_p=1$. A system contains 2 atm Cl_2 , 2 atm H_2O , 4 atm HCl and 1 atm O_2 at 600°C . Which of the following statements is correct?

- a) the system is already at equilibrium, no shift occurs
- b) to reach equilibrium, the system will be shifted to the left
- c) to reach equilibrium, the system will be shifted to the right
- d) $K_p=K_c$
- e) None of these

$\frac{2 \times 4^4}{2^2 \times 2} = 16$
 $Q = \frac{nRT}{V}$

18] The osmotic pressure of blood at 37°C is 7.7 atm. A solution that is given intravenously must have the same osmotic pressure as blood. What should be the molarity of a glucose solution to give a standard pressure of 7.7 atm at 37°C ?

- a) 0.10 M
- b) 0.90 M
- c) 0.45 M
- d) 0.30 M
- e) 1.5 M

Osmosis = MRT
 $7.7 = (37+273) \times 10^{-3} \times \pi$

19] What is the pH of a 0.29 M solution of ammonium nitrate NH_4NO_3 ; $K_b(\text{NH}_3)=1.8 \times 10^{-5}$

- a) 4.90
- b) 8.21
- c) 9.42
- d) 4.63
- e) 2.37

$\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NH}_3$
 $K_a = \frac{10^{-14}}{1.8 \times 10^{-5}}$
 $\frac{0.29 - x}{0.29} = 5.55 \times 10^{-10}$
 1.26×10^{-5}
 LEBANESE BY NATURE
 PROUD BY CHOICE

20] Consider the following equilibrium: $\text{NO} (\text{g}) + \text{O}_3 (\text{g}) \rightleftharpoons \text{NO}_2 (\text{g}) + \text{O}_2 (\text{g})$. Predict the direction in which the system will shift to reach equilibrium for the following mixture of reactants and products taken at 25°C :

$\text{NO}=3 \text{ atm}$; $\text{O}_3=0.5 \text{ atm}$; $\text{NO}_2=2 \text{ atm}$; $\text{O}_2=1 \text{ atm}$

Given data: $\Delta G^\circ (\text{NO}) = 87 \text{ kJ/mol}$, $\Delta G^\circ (\text{O}_3) = 163 \text{ kJ/mol}$, $\Delta G^\circ (\text{NO}_2) = 52 \text{ kJ/mol}$, $\Delta G^\circ (\text{O}_2) = 0 \text{ kJ/mol}$

- a) no shift occurs
- b) to the left
- c) to the right
- d) not enough information is given to answer correctly the question

$\Delta G = 10 \times 0 + 0 - 10 \times 0 - 87 - 163$
 $2 - 199$
 $\Delta G = -RT \ln K$
 $-198 = -8.31 \times (25+273) \times \ln K$
 $K = 1.33$
 to shift to the left
 5

21] In an experiment, 42.6 g of zinc at 112 °C is placed in 100 g of water, initially at 25 °C in a calorimeter. The final temperature of the water and zinc is 31.4 °C. What is the specific heat capacity of zinc in J/g.°C? The specific heat capacity of water is 4.18 J/g.°C.

- a) 0.78
- b) 0.39
- c) 0.19
- d) 0.58
- e) 0.97

$c_s = \frac{E}{DT_{\text{zinc}}}$
 $E_{\text{water}} = 4.18 \times (25 - 31.4) \times 100$
 $E = 2675.2$

22] At 25°C, $K_c = 400$ for $C(s) + O_2(g) \rightleftharpoons CO_2(g)$, what is the equilibrium partial pressure of O_2 (in atm) if CO_2 , initially at 0.5 atm, is allowed to come to equilibrium?

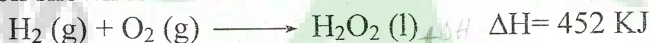
- a) 4.5×10^{-2}
- b) 6.2×10^{-4}
- c) 8.3×10^{-5}
- d) 2.5×10^{-6}
- e) 1.2×10^{-3}

$K_c = 400$
 $\frac{[CO_2]}{[O_2]} = 400$
 $\frac{0.5 - x}{x} = 400$
 $0.5 - x = 400x$
 $0.5 = 401x$
 $x = \frac{0.5}{401} \approx 1.2 \times 10^{-3}$

23] Which of the following reaction has a positive entropy change?

- a) $CaO(g) + H_2O(g) \longrightarrow Ca(OH)_2(s)$
- b) $2NO_2(g) \longrightarrow N_2O_4(g)$
- c) $CuSO_4(s) + 5H_2O(l) \longrightarrow CuSO_4 \cdot 5H_2O(s)$
- d) $PCl_5(s) \longrightarrow PCl_3(l) + Cl_2(g)$
- e) $H_2O(g) \longrightarrow H_2O(l)$

24] The reaction shown is exothermic



Which statement is correct:

- a) the reaction is a spontaneous process
- b) the reaction is a non spontaneous process
- c) it is impossible to judge on the basis of ΔH alone

$\Delta G = \Delta H - T\Delta S$
 negative

25] For which K_c value for the hypothetical equilibrium shown below does the equilibrium most strongly tend toward products?



- a) 0.015
- b) 8.1×10^{-3}
- c) 1.0
- d) 290
- e) 3.2×10^3

Bonus:

A 1 L sample of an ideal gas, originally at 710 Torr, is compressed to 0.83 L at the same temperature. What is the new pressure of the gas?

- a) 1268 Torr
- b) 655 Torr
- c) 780 Torr
- d) 855 Torr
- e) 973 Torr

$V_1 = 1 \text{ L}$
 $P_1 = 710 \text{ Torr}$
 $V_2 = 0.83 \text{ L}$
 $P_2 = ?$
 $P_1 V_1 = P_2 V_2$
 $710 \times 1 = P_2 \times 0.83$
 $P_2 = \frac{710}{0.83} \approx 855 \text{ Torr}$

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Multiple choice Questions. Choose One Answer.

	a	b	c	d	e
1	X				
2				X	
3					X
4	X			X	
5				X	
6		X			
7			X		
8					X
9	X				
10				X	
11	X				
12					X
13		X			
14				X	
15				X	
16			X		
17	X				
18				X	
19	X				
20				X	
21	X				
22					X
23				X	
24			X		
25					X
26				X	

Handwritten marks in a column next to the table, likely representing answers or scores for each question. The marks include 'X's and vertical lines.

