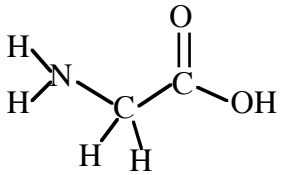
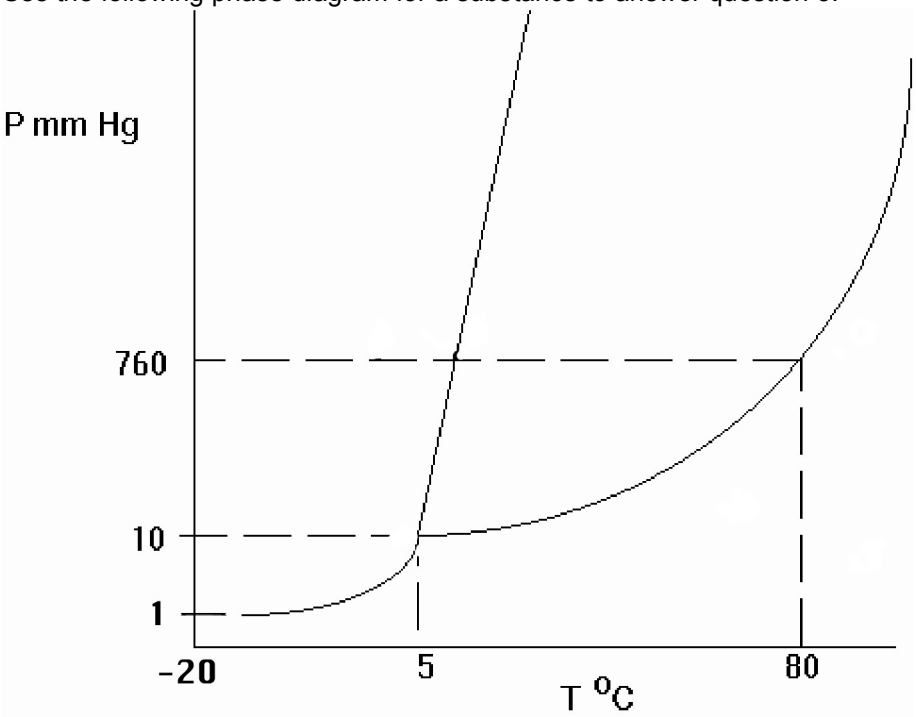
Chemistry 112, Spring 2006 Prof. Metz Final Exam Name _____
Each question is worth 4 points, unless otherwise noted

1. The predominant intermolecular attractive force in solid sodium is:
   (A) metallic
   (B) ionic
   (C) covalent
   (D) dipole-dipole
   (E) induced dipole-induced dipole



2. Glycine (shown above) would be predicted to be most soluble in which solvent:
   (A) CH_4 (B) CCl_4 (C) CCl_3H (D) C_3H_8 (E) H_2O

Use the following phase diagram for a substance to answer question 3.



3. A sample of the substance is placed in a container at a temperature of 0°C and a pressure of 500 mm Hg. The pressure is then gradually lowered to 0.5 mm Hg, at constant temperature. What phase changes does the sample go through?

   (A) liquid only
   (B) solid to gas only
   (C) solid to liquid only
   (D) liquid to gas only
   (E) solid to liquid to gas

4. 50.00 g of ethylene glycol (MW= 62.0 g/mol), a non-electrolyte, is dissolved in 500.0 g water (MW= 18.00 g/mol) to give a solution with a volume of 550.0 mL. Assume that the solution is ideal. K_{fp} for water is -1.86 °C/m.
The freezing point of this solution in °C is:
(A) –4.59° (B) –3.00° (C) –2.73° (D) –1.86° (E) –0.96°

5. Compared to pure water, at 300 Kelvin the osmotic pressure of a 0.010 M solution of NaCl is :
(Note: assume that the NaCl solution is ideal)

(A) 0.49 atm
(B) 0.25 atm
(C) 0.050 atm
(D) 0.025 atm
(E) 0.013 atm

6. The reaction
$2\ I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2\ Br^-(aq)$ was studied at 25°C. The following results were obtained where

$$\text{Rate} = -\frac{d[Br_2]}{dt}$$

$[I^-]_0$ (mol/L)	$[Br_2]_0$ (mol/L)	Initial rate (mol/L s)
0.080	0.040	12.60×10^{-3}
0.040	0.040	6.30×10^{-3}
0.080	0.020	3.15×10^{-3}

The rate equation for this reaction is:
(A) Rate = $k[I^-]$
(B) Rate = $k[I^-][Br_2]$
(C) Rate = $k[I^-]^2[Br_2]$
(D) Rate = $k[I^-][Br_2]^2$
(E) Rate = $k[I^-]^2[Br_2]^2$

7. The half life for the radioactive decay of ^{14}C is 5720 years.
If a 1.000 g sample of ^{14}C were to sit for 8000 years, how much ^{14}C would remain?

(A) 0.969 g (D) 0.379 g
(B) 0.715 g (E) 0.247 g
(C) 0.489 g

8. A proposed mechanism for the reaction of NO_2 with CO to produce NO and CO_2 is:

$NO_2 + NO_2 \rightarrow NO_3 + NO$ slow
$NO_3 + CO \rightarrow NO_2 + CO_2$ fast

The rate law consistent with this mechanism is:

(A) Rate = $k[NO_2]$
(B) Rate = $k[NO_2]^2$
(C) Rate = $k[NO_2][CO]$
(D) Rate = $k[NO_2]^2[CO]$
(E) Rate = $k[NO_3][NO]/[NO_2]^2$

Use the following thermodynamic information to answer question 9.

Species	**ΔH_f^0(298 K) kJ/mol**	**S^0(298 K) J/(K mol)**	**ΔG_f^0(298 K) kJ/mol**
$CH_4(g)$	-74.87	186.26	-50.8
$O_2(g)$	0	205.07	0
$CO_2(g)$	-393.51	213.74	-394.36
$H_2O(g)$	-241.83	188.84	-228.59

9. Calculate ΔG_{rxn} in kJ/mol at a temperature of 298 K for the reaction

$$CH_4\,(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(g)$$

(A) –572 (B) –623 (C) –674 (D) –801 (E) –902

10. The reaction

$$NO\,(g) + \frac{1}{2}\,O_2\,(g) \rightarrow NO_2\,(g)$$

has ΔH_{rxn} = -57 kJ/mol and ΔS_{rxn} = -73 J/(mol K).

What is ΔG_{rxn} in kJ/mol at 100 °C for this reaction?

(A) -30 (B) -50 (C) -64 (D) -72 (E) -84

11. The reaction

$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)}$ has K_c=11 at 600 K.

A 1 liter flask is filled with 0.01 moles of N_2, 0.03 moles of H_2 and 0.02 moles of NH_3. Will any reaction occur ? If so, is NH_3 produced or consumed ?

(A) No reaction will occur
(B) A reaction will occur; NH_3 will be consumed
(C) A reaction will occur; NH_3 will be produced

12. An aqueous solution has a pH of 4.62. The $[OH^-]$ in the solution is

(A) 2.2×10^{-1}
(B) 2.4×10^{-5}
(C) 1.0×10^{-7}
(D) 8.3×10^{-8}
(E) 4.2×10^{-10}

13. The pH of a 0.150 M solution of formic acid, HCOOH is

(K_a (formic acid) = 1.8×10^{-4}).

(A) 0.82 (C) 3.74 (E) 5.38
(B) 2.28 (D) 4.57

14. The pH of a 0.05 M solution of nitric acid, HNO_3 is
(A) 0.05 (C) 0.70 (E) 2.00
(B) 0.10 (D) 1.30

15. HBrO reacts with water via

$$HBrO + H_2O \rightleftharpoons BrO^- + H_3O^+$$

In this acid-base reaction, _____ and _____ act as Bronsted acids; while _____ and _____ are bases:

(A) HBrO, H_2O; BrO^-, H_3O^+

(B) HBrO, BrO^-; H_2O, H_3O^+

(C) HBrO, H_3O^+; H_2O, BrO^-

(D) H_2O, H_3O^+; HBrO, BrO^-

(E) BrO^-, H_3O^+; HBrO, H_2O

Question 16 refers to the following gas phase equilibrium for which K_c = 12 at 1100K and $\Delta H°$ = -198 kJ/mol.

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

16. Addition of $SO_{2\,(g)}$ to an equilibrium mixture of the three gases at constant volume and temperature would cause:
(A) K to increase and the amount of $O_{2\,(g)}$ to decrease.
(B) K to decrease and the amount of $O_{2\,(g)}$ to increase.
(C) K to decrease and the amount of $O_{2\,(g)}$ to decrease.
(D) no change in K but a decrease in the amount of $O_{2\,(g)}$.
(E) no change in K but an increase in the amount of $O_{2(g)}$.

17. 1 mole of $NH_4Cl_{(s)}$ is put into an evacuated 1 liter container at 550 K, and the following reaction occurs:

$$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$$

At equilibrium, $[NH_{3(g)}] = 2.2 \times 10^{-3}$ M. What is K_c for the reaction ?
(A) 2.4×10^{-6} (B) 4.8×10^{-6} (C) 9.6×10^{-6} (D) 1.9×10^{-5} (E) 2.2×10^{-3}

Questions 18 and 19 refer to a solution made by dissolving 0.010 mol of benzoic acid ($HC_7H_5O_2$) and 0.020 moles of sodium benzoate ($NaC_7H_5O_2$) in enough water to make 1.00 L of solution. pK_a for $HC_7H_5O_2$ is 4.20.

18. What is the approximate pH of this solution?

(A) 4.20 (C) 4.50 (E) 3.10
(B) 3.90 (D) 2.96

19. What is the approximate pH after the addition of 0.010 mol of HCl to the solution (assume no volume change)?

(A) 2.00 (C) 4.50 (E) 2.96
(B) 3.90 (D) 4.20

20. Calculate the $[ClO^-]/[HClO]$ ratio necessary to give a buffer with a pH = 8.00.
K_a for HClO is 3.5×10^{-8}
(A) 1.00 (B) 1.07 (C) 3.50 (D) 0.286 (E) 0.932

21. What is the $[Ca^{2+}]$ in a saturated $CaCO_3$ solution?
K_{sp} ($CaCO_3$) = 8.7×10^{-9}

(A) 2.1×10^{-3} M (D) 8.7×10^{-9} M
(B) 9.3×10^{-5} M (E) 4.4×10^{-9} M
(C) 6.2×10^{-7} M

22. The reaction
$2\ Al_{(s)} + 6\ H^+_{(aq)} \rightarrow 2\ Al^{3+}_{(aq)} + 3\ H_{2(g)}$ has a cell potential E^o = 1.66 V under standard conditions (1 M concentrations for solutions, 1 atmosphere pressure for gases).
What is the cell potential E when $[H^+]$ = 0.01 M, $[Al^{3+}]$ = 0.5 M and H_2 is at a pressure of 1 atmosphere?
(A) 1.64 V (D) 1.23 V
(B) 1.58 V (E) 0.99 V
(C) 1.55 V

23. The reaction

$Fe_{(s)} + 2\ H^+_{(aq)} \rightarrow Fe^{2+}_{(aq)} + H_{2(g)}$ has a cell potential $E^o = 0.44$ V under standard conditions. What is ΔG^o for the reaction, in kJ/mol?

(A) -21.2 (D) -84.9
(B) -42.4 (E) -96.2
(C) -73.1

24. Balance the following redox reaction in acidic solution
(Some of the coefficients will be zero !)
(8 pts)

___ $H_3AsO_{4(aq)}$ + ___$Cr_{(s)}$ + ___ H_2O + ___ $H^+_{(aq)} \rightarrow$
___ $H_3AsO_{3(aq)}$ + ___$Cr^{3+}_{(aq)}$ + ___ H_2O + ___ $H^+_{(aq)}$

25. There was also an Extra Credit question worth 5 points

Additional questions from Chapter 20 that were on Exam 4 in Spring 2006.
Your final exam will include questions on this material.

Questions 26 and 27 refer to the following cell:
A galvanic cell is constructed in which one half cell consists of a Cu electrode in a 1.0 M $CuSO_4$ solution and the other half cell consists of a Ag electrode in a 1.0 M $AgNO_3$ solution.

For $Cu^{2+} + 2e^- \rightarrow Cu$ the standard reduction potential $E^o = +0.34$ V
For $Ag^+ + e^- \rightarrow Ag$ the standard reduction potential $E^o = +0.80$ V

The net cell reaction is:

$Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$

26. The anode (negative electrode) reaction is:

(A) $Ag^+ + e^- \rightarrow Ag$ (D) $Cu \rightarrow Cu^{2+} + 2e^-$
(B) $Cu^{2+} + 2e^- \rightarrow Cu$ (E) $Ag^+ \rightarrow Ag^{2+} + e^-$
(C) $Ag \rightarrow Ag^+ + e^-$

27. The cell voltage is:

(A) 1.94 V (C) 0.80 V (E) 1.24 V
(B) 1.14 V (D) 0.46 V

28. In the reaction

$$MnO_4^- + Cu_2O \rightarrow MnO_3^- + CuO$$

(A) Mn is oxidized. Its oxidation number changes from +5 to +3
(B) Mn is reduced. Its oxidation number changes from +5 to +3
(C) Mn is oxidized. Its oxidation number changes from +7 to +5
(D) Mn is reduced. Its oxidation number changes from +7 to +5
(E) Mn is not oxidized or reduced. Its oxidation number is unchanged

When balancing reactions, please simplify coefficients as much as possible
If a compound doesn't appear as a reactant or a product, use a coefficient of zero.
Write all solutions on the answer sheet !

29. Balance the following redox reaction
(4 pts)

___ $Ag^+_{(aq)}$ + ___ $Cu_{(s)}$ → ___ $Ag_{(s)}$ + ___ $Cu^{2+}_{(aq)}$

30. Balance the following redox reaction in basic solution
(Some of the coefficients will be zero !)
(4 pts)

$NiO_2 + Zn_{(s)}$ + ___ H_2O + ___ $OH^-_{(aq)} \rightarrow Ni(OH)_2 + Zn(OH)_2$ + ___ H_2O + ___ $OH^-_{(aq)}$

31. Balance the following redox reaction in acidic solution
(Some of the coefficients will be zero !)
(8 pts)

___ $CrO_4^{2-}{}_{(aq)}$ + ___$SO_3^{2-}{}_{(aq)}$ + ___ H_2O + ___ $H^+_{(aq)}$ →
___ $Cr(OH)_3$ + ___$SO_4^{2-}{}_{(aq)}$ + ___ H_2O + ___ $H^+_{(aq)}$