Chm139 Practice Exam

Part A: Multiple Choice Questions [30 questions]

1. When a 1.00 g sample of a mixture of NaCl and $AlCl_3$ is treated with excess $AgNO_3$ solution, 0.02142 moles of solid AgCl are obtained. What is the percentage by mass of NaCl in the mixture? (NaCl, 58.44 $g \cdot mol^{-1}$; $AlCl_3$, 133.33 $g \cdot mol^{-1}$)

A) less than 10%
B) 20%
C) 25%
D) 31%
E) 42%

2. Which of the following sets of quantum numbers is not possible?

	n	l	m_l	m_s
A.	1	0	0	+1/2
B.	4	0	0	+1/2
C.	3	3	−3	−1/2
D.	2	1	1	−1/2
E.	2	0	0	+1/2

3. Only one of the following molecules or irons is **not** of VSEPR type AX_3. Which one is it?

A) CO_3^{2-}
B) SO_3
C) NO_3^-
D) KrF_3^+
E) BF_3

4. The minimum energy for photoemission of electrons from a potassium surface is 3.69×10^{-19}J. What is the kinetic energy of electrons emitted from a potassium surface when it is irradiated by UV light at 300nm.

A) 7.60×10^{-20}J
B) 3.69×10^{-19}J
C) 2.93×10^{-19}J
D) 6.62×10^{-19}J
E) 1.03×10^{-18}J

5. By law, microwave ovens are allowed to operate only at a fixed frequency of 2450 MHz. To cook a typical hot dog requires 27.4 kJ of heat. How many microwave photons must a typical hot dog absorb to be cooked in a microwave oven?

A) 2.17×10^{27}
B) 1.69×10^{28}
C) 2.17×10^{24}
D) 1.43×10^{8}
E) 1.68×10^{25}

6. For the reaction A + B $\rightarrow$ products, the following data were obtained.

$[A]_o$ (in mol L^{-1})	$[B]_o$ (in mol L^{-1})	Initial Rate (in mol L^{-1} min^{-1})
0.40	0.40	160.0
0.20	0.40	80.0
0.20	0.10	5.00
0.40	0.20	40.0

What is the rate law for this reaction?

A) Rate = $k[A][B]$
B) Rate = $k[A]^2[B]$
C) Rate = $k[A][B]^2$
D) Rate = $k[A]^2[B]^4$
E) Rate = $k[A]^2[B]^2$

7. The half-life of a radioactive isotope is ten days. How many days does it take for the isotope to decay to one-eighth of its original activity? (Radioactivity decay is a first-order process).

A) 20 days
B) 30 days
C) 32 days
D) 48 days
E) 80 days

8. The reaction of NO with O_2 to form NO_2 contributes to the formation of urban smog. The following mechanism has been proposed:

$NO + NO \rightleftharpoons N_2O_2$ (fast equilibrium)
$N_2O_2 + O_2 \rightarrow 2\ NO_2$ (slow)

What is the rate law derived from this mechanism?

A) Rate = constant $\times$ $[NO]^2\ [O_2]$
B) Rate = constant $\times$ $[NO]^2$
C) Rate = constant $\times$ $[NO]\ [O_2]^2$
D) Rate = constant $\times$ $[NO]\ [O_2]$
E) Rate = constant $\times$ $[O_2]^2$

9. The rate of a certain reaction is about 3.0 times faster at 50°C than at 40°C. Which of the following is the best estimate of the activation energy for the reaction?

A) 10 J mol^{-1}
B) 50 J mol^{-1}
C) 90 J mol^{-1}
D) 200 J mol^{-1}
E) 400 J mol^{-1}

10. Consider the reaction

$3Fe(s) + 4\ H_2O(g) \rightleftharpoons 4H_2(g) + Fe_3O_4(s)$

If the total pressure is increased suddenly by reducing the volume,

A) more H_2O (g) is produced
B) no change occurs
C) more H_2(g) is produced
D) more Fe(s) is produced

11. The following reaction has reached a state of dynamic equilibrium, in the presence of a catalyst.

$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3(g)$, $\Delta H = -198$ kJ

Which one of the following changes will decrease the concentration of SO_3 in the equilibrium mixture?

A) increasing the temperature
B) removing the catalyst
C) decreasing the volume of the reaction vessel
D) adding some more O_2
E) none of these

12. If 0.00300 mol NaOH and 0.00300 mol $Ba(OH)_2$ are completely dissolved in water to make 1.00 L of solution at 25ºC, what is the pOH of the solution?

A) 2.05
B) 2.22
C) 7.00
D) 11.8
E) 12.0

13. Recall the equation pH = pK_{HIn} + $\log\left(\frac{[In^-]}{[HIn]}\right)$. For the acid-base indicator HIn, $K_a = 1\times10^{-6}$. At pH = 8.0, what is the ratio of acid form of the indicator to its conjugate base form?

A) 200/1
B) 1/200
C) 50/1
D) 1/100
E) 1/1

14. Calculate the work needed to make room for products in the combustion of 1 mole of C(s) at 273 K and 1 atm. (1 L.atm = 101 J)

A) −2.26 kJ
B) no work is needed
C) −6.79 kJ
D) −4.52 kJ

15. Given the following thermochemical data at 1 atm:

$HCl(g) \longrightarrow H^+(aq) + Cl^-(aq)$ $-75.15\ kJ\cdot mol^{-1}$
$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$ $-184.62\ kJ\cdot mol^{-1}$

Determine the standard enthalpy of formation of $Cl^-(aq)$

A) $+17.16\ kJ\cdot mol^{-1}$
B) $+109.47\ kJ\cdot mol^{-1}$
C) $-167.46\ kJ\cdot mol^{-1}$
D) $+34.32\ kJ\cdot mol^{-1}$

16. What is the standard reaction enthalpy for the reaction below?

$2\ CO_2(g) \rightarrow 2\ C(s) + O_2(g)$

A) $-\Delta H^o_f[CO_2(g)]$
B) $+\Delta H^o_f[CO_2(g)]$
C) $-2\ \Delta H^o_f[CO_2(g)]$
D) $+2\ \Delta H^o_f[CO_2(g)]$
E) $+2\ \Delta H^o_f[C(s)] + \Delta H^o_f[O_2(g)]$

17. When 5.00g H_2SO_4 (formula weight, 98.09 g/mol) is dissolved in water in a calorimeter, the temperature decreases by 0.718°C. If the heat capacity of the calorimeter (and its contents) is 6.83 kJ $^oC^{-1}$, what is the molar heat of solution of H_2SO_4?

A) –481 kJ/mol
B) –10.3 kJ/mol
C) -96.2 kJ/mol
D) –0.526 kJ/mol
E) –0.981 kJ/mol

18. The reaction $CO(g) + ½\ O_2(g) \rightarrow CO_2(g)$

is extremely important in efforts to reduce poisonous emissions from automobile exhausts. At constant T and P, which of the following is correct for this reaction?

A) w = 0
B) $\Delta H = \Delta U$
C) ΔH is less than ΔU
D) ΔH is greater than ΔU
E) ΔH is independent of the physical states of the reactants and products.

19. "Spontaneous change is always accompanied by an increase in entropy". The entropy change referred to in this statement is:

A) ΔS_{system}
B) $\Delta S_{uinverse}$
C) $\Delta S_{surroundings}$
D) $\Delta S_{zero\ Kelvin\ temperature}$

20. The vapor pressure of formic acid, $HCOOH_{(l)}$, at 25°C is 11.4 Torr.

$HCOOH_{(l)} \rightarrow HCOOH_{(g)}$ (11.4 Torr)

The change in free energy for the reaction, ΔG_r, at 25°C is:

A) + (0.008314)(298) ln (1) = 0
B) + (0.008314)(298) ln (11.4) = 6.03kJ/mol
C) – (0.008314)(298) ln (11.4) = -6.03kJ/mol
D) – (0.008314)(298) ln (0.015) = 10.4kJ/mol
E) + (0.008314)(298) ln (0.015) = -10.4kJ/mol

21. Which of the following reactions has the largest positive molar entropy change?

A) $4NH_{3(g)} + N_{2(g)} \rightarrow 3N_2H4_{(l)}$
B) $C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}$
C) $NH_4NO_{3(s)} \rightarrow NH4^+_{(aq)} + NO^-_{3(aq)}$
D) $Na_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(s)} + ½\ H_{2(g)}$
E) $N_{2(g)}$ (1atm, 25°C) $\rightarrow N_{2(g)}$ (10atm, 25°C)

22. When sulfur, $S_8(s)$, burns in oxygen to produce $SO_2(g)$ under standard conditions it generates 2375 kJ of heat per mole of S_8 burned. What is the standard molar enthalpy of formation of $SO_2(g)$?

A) 297 kJ/mol
B) 2375 kJ/mol
C) –2375 kJ/mol
D) 594 kJ/mol
E) –297 kJ/mol

23. The N_2, F_2, and N–F bond enthalpies are 944, 158, and 272 $kJ \cdot mol^{-1}$ respectively. Calculate the enthalpy of formation of $NF_3(g)$.

A) +365
B) −1525
C) −816
D) −107

24. Which one of the following statements is **true?**

A) ΔH is always equal to q.
B) ΔH is always equal to ΔU.
C) ΔH equals to ΔU for a reaction which is carried out at constant volume.
D) ΔH equals q for a reaction which is carried out at constant pressure.
E) ΔH for an endothermic reaction is negative.

25. Given the following standard reduction potentials

$2HIO_3(aq) + 10H^+ + 10e^- \rightarrow I_2(s) + 6H_2O(l)$ $E^\circ = +1.20V$

$ClO_3^-(aq) + 6H^+ + 6e^- \rightarrow Cl^- + 3H_2O$ $E^\circ = +1.45V$

The standard cell potential for the reaction

$3I_2(s) + 5ClO_3^- + 3H_2O(l) \rightarrow 6HIO_3(aq) + 5Cl^-$ is

A) +0.25V
B) –2.48V
C) +2.65V
D) –3.65V
E) +3.65V

26. In a redox reaction, the reducing agent:

A) gains electrons and is reduced
B) gains electrons and is oxidized
C) contains an element that undergoes a decrease in oxidation number
D) loses electrons and is reduced
E) loses electrons and is oxidized

27. Consider the reaction

$2Ag^+(aq) + Ni(s) \rightarrow 2Ag(s) + Ni^{2+}(aq)$ $E^\circ_{cell} = +1.06V$

If E° for the Ag reduction half-reaction is +0.80V, the standard reduction potential for

$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ at 25°C

in V, must be…

A) –0.28
B) –0.26
C) +0.54
D) –0.54
E) +0.26

28. If an alkaline dry cell provides a steady current of 0.40A for ten hours, through the reaction

$Zn(s) + 2MnO_2(s) \rightarrow ZnO(s) + Mn_2O_3(s)$

the mass in g of zinc metal consumed is…

A) 4.9
B) 2.4
C) 9.8
D) 20
E) 1.2

29. A strip of copper is placed in a 1 M solution of copper nitrate and a strip of silver is placed in a 1M solution of silver nitrate. The two metal strips are connected to a voltmeter by wires and a salt bridge connects the solutions. The following standard reduction potentials apply:

$Ag^+ (aq) + e^- \longrightarrow Ag (s) \quad E^O = +0.80\ V$
$Cu^{2+} (aq) + 2e^- \longrightarrow Cu (s) \quad E^O = +0.34\ V$

When the voltmeter is removed and the two electrodes are connected by a wire, which of the following <u>*does not*</u> take place?

A) Electrons flow in the external circuit from the copper electrode to the silver electrode.
B) The silver electrode increases in mass as the cell operates.
C) There is a net general movement of silver ions through the salt bridge to the copper half-cell.
D) Negative ions pass through the salt bridge from the silver half-cell to the copper half-cell.
E) Some positive copper ions pass through the salt bridge from the copper half-cell to the silver half-cell.

30. What is the volume of the H_2 gas at 25°C and 1.00 atm that will collect at the cathode when an aqueous solution of Na_2SO_4 is electrolyzed for 2.00 hours with a current of 10.0 A?

$H_2O_{(aq)} + 2e^- \leftrightarrow H_{2(g)} + 2OH^-_{(aq)}$

A) 9.13L
B) 0.373L
C) 18.26L
D) 4.55L
E) 0.766L

Part B: Written Answer Questions [4 questions]

1. Iron crystallizes in one of the cubic lattice arrangements. The edge length of the unit cell is 287 pm. The density of iron is 7.86 gcm^{-3} at 298K and its molar mass is 55.847$gmol^{-1}$. What type of lattice does iron form? Show your reasoning.

2. If you have a buffer solution made up of 0.25mol hypochlorous acid (HOCl),
Ka=3.0 x 10^{-8}, and 0.40mol sodium hypochlorite (NaOCl) in 1.0L of water, calculate the change in pH of this solution after 0.12mol of NaOH are added. Assume no volume change.

3. Exposure of metallic iron to moist air results in the formation of rust, one component of which is iron(III) oxide, Fe_2O_3 Metallic iron can be recovered from iron(III) oxide by heating it in the presence of solid graphitic carbon:

$$2Fe_2O_3(s) + 3C(graphite) \rightleftharpoons 4Fe(s) + 3CO_2(g)$$

For the substances involved in this reaction we have the following data at 25°C:

Substance	$\Delta H°_f$ (kJ mol^{-1})	$S°$(J mol^{-1} K^{-1})
$Fe_2O_3(s)$	-824.2	87.4
C(graphite)		5.7
Fe(s)		27.3
$CO_2(g)$	-393.5	213.7

Assume ideal behavior.

(a) Calculate ΔH° for the above reaction at 25°C.

(b) Calculate ΔS° for the above reaction at 25°C.

(c) Account for the algebraic sign of ΔS° for the above reaction.

(d) Calculate ΔG° for the above reaction at 25 °C.

(e) Calculate the equilibrium constant, K, for the above reaction at 25°C.

(f) Determine the temperature above which this reaction would become spontaneous under standard state conditions.

4. Consider an electrochemical cell at 25 °C which uses the chemical reaction:

$Zn(s) + Ni^{2+}(aq, 0.0010M) \rightarrow Ni(s) + Zn^{2+}(aq, 0.10M)$

to which the following standard reduction potentials apply

$$\left\{ \begin{array}{lll} Ni^{2+}(aq) + 2e^- & Ni(s) & \varepsilon_{298}{}^0 = -0.23 \text{ volt} \\ Zn^{2+}(aq) + 2e^- & Zn(s) & \varepsilon_{298}{}^0 = -0.76 \text{ volt} \end{array} \right\} \quad \varepsilon_{cell}{}^0 = 0.53 \text{ volt}$$

(a) Calculate the value for the reaction quotient, Q, for the cell reaction, as written above.

(b) Determine the cell potential at 25°C.

c) Calculate ΔG for the cell at 25 °C.

d) Specify the composition of the electrode at which reduction occurs during the spontaneous operation of the cell.