Chemistry 1266 Exam II

Spring 2009
Chapters 12. 13 & 14*

Name (PRINTED LEGIBLY)_____

Student ID Number_____

Please read and acknowledge the following instructions.

1. There is a periodic table attached to this exam. You may tear it off the exam, however all exam materials are to be turned in with the exam.
2. You will have 1 hour, 50 minutes to complete the exam.
3. You are responsible for any corrections announced during the first hour of the exam.
4. Anyone arriving more than 15 minutes late will not be allowed to take the exam.
5. You are only allowed a single-line, non-programmable calculator on this exam.
6. **No cell phones, PDAs, or music devices** of any kind are allowed during the exam
7. Use the spaces between questions and the backs of the exam page for scratch paper. No additional scratch paper is allowed.
8. Are problems are valued at 4 points each, except where specifically noted.
9. This exam consists of 12 pages total (cover sheet, test pages, misc. information and periodic table). Be sure you have all 12 pages.
10. During the exam if you have a question please raise your hand and the instructor or proctor will come to you.

Signature_____

Date: _____

Chemistry 1266 Exam I

Spring 2009
Chapters 12, 13 & 14*: Gilbert, Kirss & Davies

Name: _____

There is a periodic table and a section of miscellaneous information at the end of this exam. Show work for all problems requiring dimensional analysis, circle your answer for multiple choice questions on this test form. **NO PROGRAMABLE (Graphing) CALCULATORS.**

1. (3 points) Professor Frank "Happy" Gilmore has invented a catalyst that promotes rearrangement of alkanes. Depending on the conditions used, it can promote either the conversion of normal alkanes to their branched isomers or the conversion of branched alkanes to their normal alkane isomers. Which reaction would make Professor Gilmore's invention worth more to an oil company?

a. The catalyst would be worthless to an oil company.
b. The conversion of branched chain alkanes to normal isomers is more valuable.
c. The conversion of normal alkanes to branched chain isomers is more valuable.
d. Both would be equally valuable.

2. (3 points) Which of the following is not likely to be a component of a natural gas deposit?

a. CH_4
b. C_4H_{10}
c. C_4H_8
d. C_6H_{14}

3. A solution of 0.10 mol of compound X ($P° = 100$ torr at 20°C) and 0.10 mol of compound Y ($P° = 50$ torr at 20°C) is prepared, and its vapor pressure is measured to be 60 torr at 20°C. What is true about this solution?

a. It is an ideal solution.
b. It is a non-ideal solution.
c. Compound X and compound Y exhibit little intermolecular attraction for one another.
d. b and c

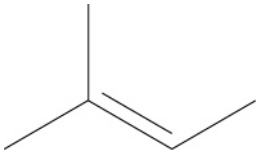
4. (3 points) Name the compound.

a. *trans*-4-hexene
b. *cis*-3-hexene
c. *trans*-3-hexene
d. *cis*-4-hexene

5. (3 points) Aromatic hydrocarbons are particularly stable due to:

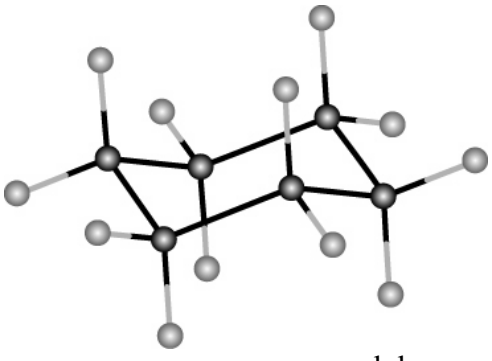
a. delocalized bonding electrons.
b. small proportions of hydrogen in their formulas.
c. their covalent network bonding.
d. all the above.

6. Does this molecule have both cis and trans isomers?



a. Yes, this is the *cis* isomer.
b. Yes, this is the *trans* isomer.
c. No, it has only the *cis* isomer.
d. No, it has no geometric isomers

7. (3 points) Name this molecule.



a. dodecane
b. cyclohexane (boat conformation)
c. cyclohexane (chair conformation)
d. puckerane

8. The entropy change in a system (ΔS_{sys}) _____ during a spontaneous process.

a. is positive
b. is negative
c. is zero
d. All three of the above answers are possible.

9. (3 points) $\Delta S_{surroundings}$ is related to heat (enthalpy) in the system by:

a. $-q_{surr}/T = \Delta S_{surr}$
b. $q_{sys}/T = \Delta S_{surr}$
c. $-q_{sys}/T = \Delta S_{surr}$
d. $q_{surr}/T = \Delta S_{surr}$

10. If 3.500 g of Ni are reacted with excess oxygen to form nickel oxide (NiO), what is the standard entropy change for the reaction?

$$2\,Ni(s) + O_2(g) \rightleftharpoons 2\,NiO(s)$$

Substance	***S*° (J/mol · K)**
Ni(s)	182.1
O_2 (g)	205.0
NiO(s)	37.99

11. At what temperature (K) is the given reaction at equilibrium? Assume $\Delta H°$ and $S°$ do not change with temperature.

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

given

Substance	**$\Delta H°$ (kJ/mol)**	**$S°$ (J/mol · K)**
$NO_2(g)$	33.2	240.0
$N_2O_4(g)$	9.2	304.2

12. (3 points) Boltzmann derived the relationship, $S = k\ln W$ where W is:

a. the number of microstates.
b. vibrational energy.
c. kinetic energy.
d. potential energy.

13. A molecule of chlorine has energy microstates involving _____, _____, and _____ modes of motion.

a. translational, rotational, kinetic energy
b. kinetic energy, potential energy, translational
c. rotational, vibrational, potential energy
d. translational, rotational, vibrational

14. If 1 mol of ice melts at its melting point of 273 K, the entropy change for the ice is 22.0 J/K. If the ice melts in someone's hand at 34°C, what is the change in the entropy of the universe? The enthalpy of fusion for ice is 6.01 kJ/mol.

15. A reaction

$$A(g) \rightarrow B(g) + C(g)$$

has the following standard thermodynamic parameters:

$$\mathbf{\Delta H^\circ_{rxn} = 40.0\ kJ/mol} \text{ and } \mathbf{\Delta S^\circ_{rxn} = 80.0\ J/mol \cdot K.}$$

a. Is the reaction exothermic or endothermic?

b. Does the positive entropy change make sense? Why?

c. Is the reaction spontaneous at all temperatures? If not, explain.

d. If the answer to part (c) is "no", then calculate the temperature at which the reaction becomes spontaneous.

16. Processes with _____ and _____ are always spontaneous.

a. $\Delta H > 0$ and $\Delta S < 0$
b. $\Delta H < 0$ and $\Delta S < 0$
c. $\Delta H > 0$ and $\Delta S > 0$
d. $\Delta H < 0$ and $\Delta S > 0$

17. If the rate of formation of ammonia is 0.345 *M*/s, what is the rate of disappearance of N_2?

$$\frac{1}{2}\,N_2(g) + \frac{3}{2}\,H_2(g) \rightarrow NH_3(g)$$

18. The rates of chemical reactions

a. are constant.
b. decrease as the concentration of reactants decreases.
c. decrease as the concentration of products increases.
d. Both b and c are correct.

19. Determine the order of the reaction in each of the reactants (i.e. Rate Law) and overall order for the reaction:

$$2\,NO(g) + Cl_2(g) \rightarrow 2\,NOCl(g)$$

from the following data:

Experiment	**[NO] (*M*)**	**[Cl_2] (*M*)**	***Rate* (*M*/s)**
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

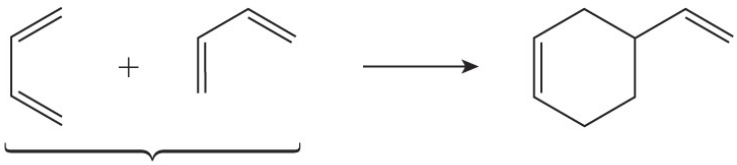
20. Given the following data, determine the rate constant, *k*, of the reaction:

$$H_2(g) + 2\,ICl(g) \rightarrow I_2(g) + 2\,HCl(g)$$

Experiment	[H_2] (torr)	[ICl] (torr)	*Rate* (torr/s)
1	250	325	1.34
2	250	81	0.331
3	50	325	0.266

21. A reaction is first order in A. If the rate constant of the reaction is $3.45 \times 10^{-3}\ s^{-1}$, what is the half-life ($t_{½}$) of the reaction?

22.



$2\ C_4H_6$
(Butadiene)

C_8H_{12}

(3 points) The condensation reaction of butadiene has a rate constant of **0.93 L/mol · min**. If the initial concentration of C_4H_6 is 0.250 M, find the time (in minutes) at which the concentration will be 0.0100 M.

23. Collision theory assumes that the rate of a reaction depends on:

a. the energy of collisions.
b. the orientation of colliding molecules.
c. the energy of collisions and the orientation of colliding molecules.
d. the change in energy between the products and the reactants.

24. (a) Given the following data for the reaction A → B, determine the activation energy, E_a, for the reaction.

k (M/s)	T (K)
0.730	250
0.733	300
0.736	350
0.737	400
0.739	450

(b) Determine the frequency factor (A) from the previous reaction data.

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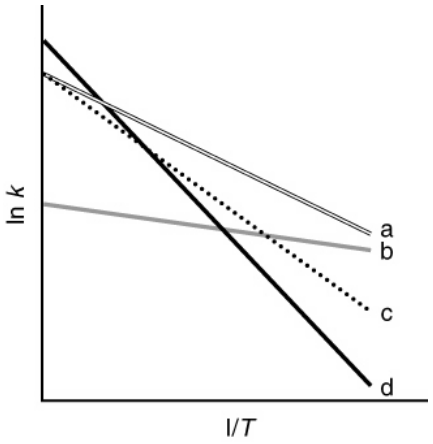
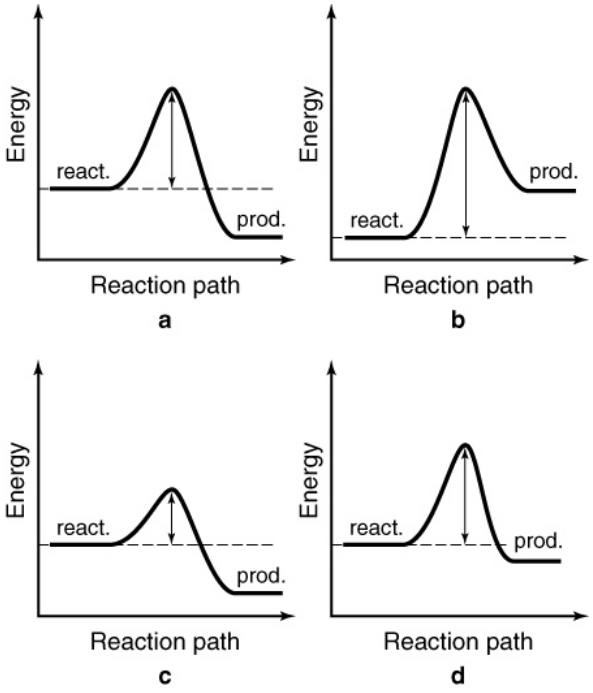
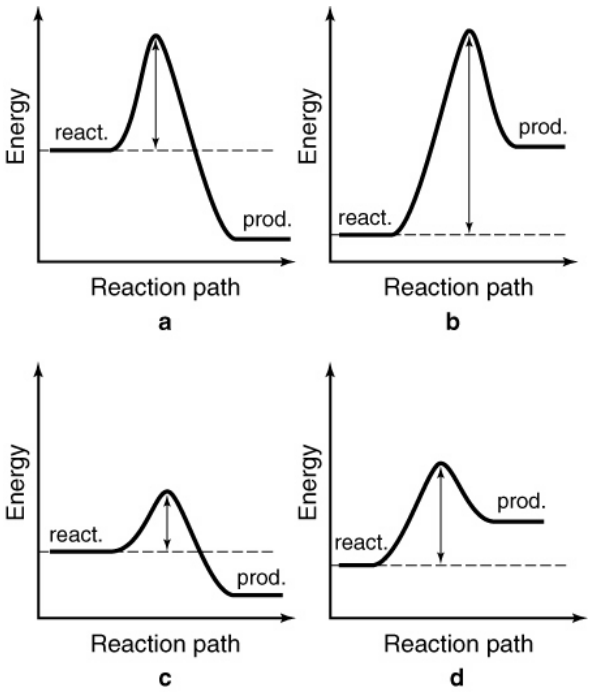
25. (3 points) The following figure shows Arrhenius plots for four different reactions. Which reaction has the greatest activation energy?



26. The following energy profiles for four different reactions are shown. Which of the reactions will have the largest rate constant?



27. The following energy profiles for four different reactions are shown. Which reaction is the most exergonic?



Extra Credit (5 points)

The following mechanism has been proposed for the gas-phase reaction of chloroform ($CHCl_3$) and chlorine:

(1) $Cl_2(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2\ Cl(g)$ (fast)

(2) $Cl(g) + CHCl_3(g) \xrightarrow{k_2} HCl(g) + CCl_3$ (slow)

(3) $Cl(g) + CCl_3 \xrightarrow{k_3} CCl_2$ (fast)

(a) What is the overall reaction?

(b) What is the molecularity of each elementary reaction?

(c) What is the rate-law predicted by this mechanism that could be experimentally tested?

Miscellaneous Information and Formulae:

$R = 0.082057\ L \cdot atm/(mole \cdot K) = 8.314\ J/(mole \cdot K)$

$N_A = 6.0221E23/mole$ $\qquad E = 2.31 \times 10^{-19}\ J \cdot nm[(Q_1 \cdot Q_2)/d]$

$\ln([A]_t/[A]_0) = -kt$ $\qquad \ln A_t = \ln A_0 - kt$ $\qquad t_{1/2} = \ln(2)/k$ $\qquad l/[A]_t - l[A]_0 = kt$

$t_{1/2} = 1/k[A]_0$ $\qquad k = A \cdot e^{-Ea/RT}$ $\qquad \ln(k) = -(E_a/RT) + \ln(A)$

$\ln(k_2/k_1) = (E_a/R)[(l/T_1) - (1/T_2)]$

$\Delta G = \Delta H - T\Delta S$ $\qquad \Delta G^o_{rxn} = \sum n\Delta G^o_{f,prod} - \sum n\Delta G^o_{f,react}$