CHEM 202 – 01,02,03,04

EXAM 2, Fall 2015

Name___________________________

Signature________________________

SCORED GRADE (75 max.)__________

CIRCLE YOUR COURSE SECTION IN THE LIST BELOW

202-01 M 12-12:50 202-02 T 12-12:50 202-03 W 1-1:50 202-04 W 12-12:50

Section 1. TRUE OR FALSE (3 pts × 10 = 30 pts)

Indicate whether each statement is True (T) or False (F). Be certain to T or F is clearly indicated.

_____ 1. For a collision of reactants to result in a reaction, the particles must collide with the correct orientation and enough energy to overcome the activation energy of the reaction.

_____ 2. For a spontaneous reaction, $\Delta H_{univ} = 0$ and $\Delta S_{univ} > 0$.

_____ 3. In a multi-step reaction, an intermediate appears on the reaction energy diagram as an energy minimum.

_____ 4. An endothermic reaction that results in an increase of entropy of the system is always endergonic.

_____ 5. A reaction with a rate constant of $3.44 \times 10^{-4}\ M^{-1}\ s^{-1}$ is first-order reaction.

_____ 6. The rate of a first-order reaction always decreases as the reaction progresses.

_____ 7. For a reaction under non-standard conditions $Q \neq 1$ and $\Delta G \neq \Delta G°$.

_____ 8. For a reaction with $\Delta H° = 25.2$ kJ/mol and $\Delta S° = 135$ J/mol K, the reaction is spontaneous at $T < 187$ K.

_____ 9. The sign of $\Delta S°$ for the condensation of any gas is positive.

_____ 10. At equilibrium, $\Delta G = 0$ and the rate of the forward reaction equals the rate of the reverse reaction.

Section 2. OPEN ANSWER (5 pts × 4 = 20 pts)

Write the correct answer on the line provided. Be certain to clearly indicate your answer.

1. Consider the following reaction:

$$2\ CH_3OH_{(g)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 4\ H_2O_{(g)}$$

   a. Which molecule has the largest standard molar entropy? ___________________________

   b. What is the sign of $\Delta S°$ for the reaction? ___________________________

2. Write a reaction quotient Q for the following reactions:

   a. $2\ HI_{(g)} \rightleftarrows H_{2(g)} + I_{2(g)}$

   ____

   b. $CaCO_{3(s)} \rightleftarrows CaO_{(s)} + CO_{2(g)}$

   ____

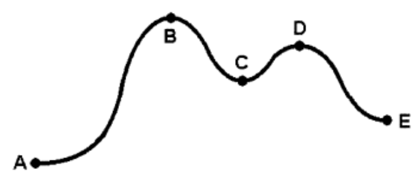
3. Given the following rate law, fill in the blanks below. Rate = $k[A]^2[B]$

   When the concentration of B is doubled, the rate of the reaction ______________________.

   The reaction is ____________________ order in A.

   The rate constant has units of ___________________________.

4. Use the points A – E on the Reaction Energy Diagram to the answer the following questions:



What point represents the reactants? ____________________

What point represents the reaction intermediates? ____________________

What two points are used to determine ΔH_{rxn}? ____________________

What two points are used to determine $E_{a,fwd}$ of the second step? ____________________

What two points are used to determine $E_{a,rev}$ of the first step? ____________________

Section 3. MULTIPLE CHOICE (5 pts × 5 = 25 pts)

Circle the correct answer. Be certain to clearly indicate your answer.

Standard Values	
$\Delta H_f°\ SO_{2(g)}$	-297 kJ/mol
$\Delta H_f°\ O_{2(g)}$	0 kJ/mol
$\Delta H_f°\ SO_{3(g)}$	-396 kJ/mol
$S°\ SO_{2(g)}$	248 J/mol K
$S°\ O_{2(g)}$	205 J/mol K
$S°\ SO_{3(g)}$	257 J/mol K

1. From the information provided to the right, calculate $\Delta G°_{rxn}$ at 25 °C for:

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

+142 kJ/mol	+385 kJ/mol	+11 kJ/mol	-142 kJ/mol
-11 kJ/mol	-385 kJ/mol	-254 kJ/mol	+254 kJ/mol

2. Use the information provided on the right to calculate the boiling point of CS_2.

Standard Values	
$\Delta H_{vap}°$	29 kJ/mol
$\Delta G_{vap}°$	3.3 kJ/mol
$\Delta S_{vap}°$	87 J/mol K

29 °C	8.8 °C	96 °C	330 °C
60. °C	250 °C	100. °C	120 °C

3. Using the information provided for question 2, what is the equilibrium vapor pressure of CS2 at 25.0 °C?

0.0020 atm	3.8 atm	0.0075 atm	0.26 atm
0.0 atm	0.052 atm	0.35 atm	2.6 atm

4. The following reaction has a rate constant (k) of 0.68 $M^{-1}\ s^{-1}$ at 500 K. The reaction proceeds via a single, elementary step. If the initial concentration of $NO_{2(g)}$ is 0.043 M, what concentration of $NO_{2(g)}$ remains after 2.5 minutes? $2\ NO_{2(g)} \rightarrow NO_{(g)} + NO_{3(g)}$

6.8×10^{-3} M	5.2×10^{-3} M	1.4×10^{-3} M	7.7×10^{-3} M
8.2×10^{-3} M	3.8×10^{-3} M	4.4×10^{-3} M	2.5×10^{-3} M

5. The decomposition of $HI_{(g)}$ to $H_{2(g)}$ and $I_{2(g)}$ proceeds with a rate constant (k_1) of $9.51 \times 10^{-9}\ M^{-1}\ s^{-1}$ at 500. K and a rate constant (k_2) of $1.10 \times 10^{-5}\ M^{-1}\ s^{-1}$ at 600. K. Calculate the activation energy for this reaction.

152 kJ/mol	163 kJ/mol	176 kJ/mol	144 kJ/mol
139 kJ/mol	128 kJ/mol	108 kJ/mol	112 kJ/mol

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USE THE BACK FOR SCRATCH PAPER IF NEEDED

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

$S = k \ln W$

$k = 1.381 \times 10^{-23}$ J/K

$R = 8.314$ J/mol K

$$\Delta G = \Delta G° + RT \ln Q$$

$$K = e^{-\Delta G°/RT}$$

$$\ln \frac{[A]_0}{[A]_t} = akt$$

$$\frac{[A]_0}{[A]_t} = e^{akt}$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = akt$$

$$t_{1/2} = \frac{\ln 2}{ak}$$

$$t_{1/2} = \frac{1}{ak\,[A]_0}$$

$$k = A\, e^{-E_a/RT}$$

$$\ln \frac{k_2}{k_1} = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$