Chemistry 1266 Exam II

1. (4 pts) What is the empirical formula of an unknown compound containing only carbon, hydrogen and oxygen when 2.98 g of CO_2 and 1.52 g of H_2O are produced from the complete combustion of 1.163 g of the compound?

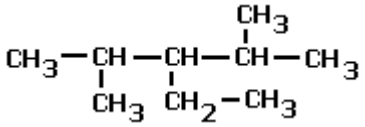
   a. **$C_6H_{15}O$** b. $C_7H_{14}O_2$ c. $C_8H_{16}O$ d. $C_7H_{15}O$

2. (3 pts) The correct (IUPAC) name for the following compounds is _____.

   a. 2,3-diethyl cyclobutane b. **1,2-dimethyl cyclopentane**

   c. 1,2-dimethyl Cyclohexane d. 1,1-dimethyl cycloheptane

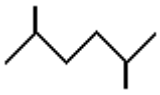
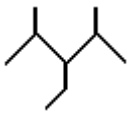
3. (3 pts) The correct (IUPAC) name for the following compounds is _____.

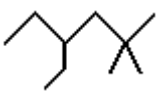


   a. 3-ethyl-2,3-dimethylhexane b. 3-methyl-2,4-diethylpentane

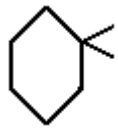
   c. 3-isopropyl-2,2-dimethylbutane d. **3-ethyl-2,4-dimethylpentane**

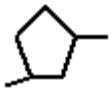
4. (3 pts) The correct line structure for 2,5-dimethylhexane would look like which of the following?

a.  b. 

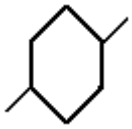
c.  d. 

5. (3 pts) The correct line structure for <u>1,4-dimethylcyclohexane</u> would look like which of the following?

a. 

b. 

c. 

<u>d.</u> 

6. (3 pts) Which reaction below should have $\Delta S^o > O$?

a. $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

b. $2\ NO_2(g) \rightarrow N_2O_4(g)$

c. $H^+(aq) + F^-(aq) \rightarrow HF(aq)$

<u>d.</u> $BaF_2(s) \rightarrow Ba^{2+}(aq) + 2\ F^-(aq)$

e. $2\ Hg(\ell) + O_2(g) \rightarrow 2\ HgO(s)$

7. (2 pts) Which of the following processes causes an entropy decrease?

a. boiling water to form steam

b. dissolution of solid KCl in water

c. mixing of two gases into one container

<u>d.</u> freezing water to form ice

8. (4 pts) Some standard entropies (at 25ºC in J/mol K) are given:
Fe(s) 27.15, $Cl_2(g)$ 222.96, $FeCl_3$ (s) 142.3.

ΔS º for the following reaction at 25 ºC in J/K is

$$2\ Fe(s) + 3\ Cl_2\ (g) \rightarrow\ 2\ FeCl_3(s)$$

a. -438.6 b. +107.8 c. -107.8

d. -380.0 e) +380.0

9. (2 pts) Consider the following reaction

$$A + B \rightarrow C$$

This reaction will always be spontaneous when ΔH is _____ and ΔS is _____

a. +, + b. -, - **c. -, +** d. +, -

10. (4 pts) The change in entropy for the vaporization of CCl_4 is +85.7 J/K·mol and the boiling temperature is 77 ºC. What is the heat of vaporization?

a.) +245 kJ/mol b. **+30.0 kJ/mol** c.) +4.08 kJ/mol

d. -245 kJ/mol e. +1,110 kJ/mol

11. (4 pts) For the formation reaction: ½ $N_2(g)$ + 3/2 $H_2(g) \rightarrow$ $NH_3(g)$ use values of ΔH^o_f and $\Delta S\ ^o_f$ to calculate the free energy change at 25 ºC.

Compound	$\Delta S\ ^o_f$(J/Kmol)	$\Delta H\ ^o_f$(kJ/mol)
$N_2(g)$	192	0
$H_2(g)$	101	0
$NH_3(g)$	193	-46

a. -53.3 kJ b. +29.6 kJ c. +53.3 kJ

d. **-29.6 kJ** e. -16.5 kJ

12. (4 pts) Calculate the free energy for the reaction of hydrochloric acid with ammonia using $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

Compound	$\Delta G\ ^\circ_f$(kJ/Mol)
HCl(g)	-95
$NH_3(g)$	-17
$NH_4Cl(s)$	-203

a. -284.9 kJ b. +100.1 kJ c. **-91 kJ**

d. +284.9 kJ e. -100.1 kJ

13. (2 pts) If ΔG is negative at all temperatures then ΔS is _____ and ΔH is _____

a. **positive, negative** b. zero, large c. negative, positive

d. large, zero e. small, large

14. (3 points) According to the Second Law of Thermodynamics, the change in the entropy of the universe (ΔS_{univ}) during a spontaneous reaction is;

a) zero
b) negative
c) **positive**
d) less than the change in entropy of the system (ΔS_{sys})

15. (3 points) Indicate which of the following has the *lowest* standard molar entropy (˚S).

a) CH_4 (g)
b) CH_3CH_2OH (?)
c) H_2O (s)
d) **Na (s)**

16. (3 points) Indicate which of the following reactions results in a positive ΔS.

a) $AgNO_3$ (aq) + NaCl (aq) ↔ AgCl (s) + $NaNO_3$ (aq)
b) HCl (g) + H_2O (ℓ) ↔ HCl (aq)
c) H_2 (g) + I_2 (g) ↔ 2 HI (g)
d) **$C_2H_2O_2$ (g) ↔2 CO (g) + H_2 (g)**

18. (4 points) 2.00 mol of sodium metal is placed in a container and reacted with 4.00 mol of chlorine gas. Determine ΔS°_{rxn} for 2 Na (s) + Cl_2 (g) ↔ 2 NaCl (s) given

Substance	**S° (J/K mol)**
Na (s)	52.45
Cl_2 (g)	222.96
NaCl (s)	72.33

a) **<u>-183.2 J/K mol</u>**
b) -91.6 J/K mol
c) -724.8 J/K mol
d) -45.3 J/K mol

19. (3 points) $\Delta S_{surroundings}$ is related to heat by:

a) $-q_{surroundings}/T = \Delta S_{surroundings}$
b) $q_{system}/ T = \Delta S_{surroundings}$
c) $-q_{system}/ T = \Delta S_{surroundings}$
d) **<u>$q_{surroundings}/T = \Delta S_{surroundings}$</u>**

20. (3 points) A reaction with $\Delta G < 0$ is

a) **<u>exergonic</u>**
b) endergonic
c) exothermic
d) endothermic

21. (3 points) A system is at equilibrium at a given temperature when

a) $\Delta S = 0$
b) **<u>$\Delta G = 0$</u>**
c) $\Delta H = 0$
d) $\Delta U = 0$

22. (4 points) Dinitrogen tetroxide (N_2O_4) decomposes to nitrogen dioxide. If $\Delta H^\circ = 58.02$ kJ/mol and $\Delta S^\circ = 176.1$ J/K mol, at what temperature is this reaction at equilibrium?

a) **<u>56.3 °C</u>**
b) 329.5 °C
c) -272.7°C
d) 25.0°C

23. (5 points) Determine ΔG_{rxn} for

C_4H_{10} (ℓ) + 13/2 O_2 (g) ↔ 4 CO_2 (g) + 5 H_2O (g) given

Substance	**ΔG°_r (kJ/Mol)**
C_4H_{10} (ℓ)	-15.0
CO_2 (g)	-384.4
H_2O (g)	-228.57

a) -608.0 kJ/mol
b) **-2665 kJ/mol**
c) -1791 kJ/mol
d) -3457 kJ/mol

24. (3 pts) In the reaction given below, the concentration of nitrogen dioxide drops from 0.0100 to 0.00650 M in 100.0 s. What is the average rate of disappearance on NO_2 for this period in M/s?

$$2NO_2(g) \rightarrow 2NO(g) + O_2(g)$$

a. 0.35 b. 0.0035 c. **3.5 E-5** d. 0.0070 e. 0.0018

25. (3 pts) In the reaction given below, which average rate relationship is *incorrect*?

$$CO(g) + 3H_2(g) \rightarrow CH_4(g) + H_2O(g)$$

a. $-\Delta[CO]/\Delta t = -\Delta[H_2]/3\Delta t$

b. **$\Delta[CH_4]/\Delta t = -\Delta[H_2O]/\Delta t$**

c. $-\Delta[CO]/\Delta t = \Delta[H_2O]/\Delta t$

d. $-\Delta[H_2]/3\Delta t = \Delta[H_2O]/\Delta t$

e. $-\Delta[CO]/\Delta t = \Delta[CH_4]/\Delta t$

26. (4 pts) Kinetic data for the following reaction was determined experimentally. What is the rate law expression for the reaction?

$$4NO_2(g) + O_2(g) \rightarrow 2N_2O_5(g)$$

Experiment #	$[NO_2]_0$ mol/L	$[O_2]_0$ mol/L	Initial Rate M/s
1	0.40	0.10	3.1
2	0.20	0.10	0.78
3	0.10	0.40	3.1

a. $k= [NO_2]^2[O_2]$ b. $k = [NO_2][O_2]^2$ c. $rate = k[NO_2]^2[O_2]$

d. $rate = k[NO_2][O_2]^2$ **e. $rate = k[NO_2]^2[O_2]^2$**

27. (3 pts) For the reaction given below, the initial concentrations of the two reactants are $[A]_0 = 0.23$ M and $[B]_0 = 0.17$ M and the initial reaction rate is 0.33 M/s. Assume the reaction is first order in both reactants. What is the value of the reaction rate constant (k)?

$$A + 2B \rightarrow C$$

a. 0.12 b. 19 c. 27 **d. 8.4**

28. (3 pts) The correct unit for the rate constant in the following rate law, where the concentrations are in mol/L and the time is in seconds is

$$rate = k[D][X]$$

a. $mol\ L^{-1}\ s^{-1}$ **b. $L\ mol^{-1}\ s^{-1}$** c. $mol^2\ L^{-2}\ s^{-1}$

d. $mol\ L^{-1}\ s^{-2}$ e. $L^2\ mol^{-2}\ s^{-1}$

29. (4 pts) The following reaction follows first-order kinetics with k= 49.8/hr. If the initial concentration of X is 3.6 M, what is the concentration of X after 15. minutes?

a. 0.046 M b. 0.230 M c. 0.11 M

d. **1.4 E-5 M** e. 0.327 M

30. (3 pts) If the half-life of a first order process is 3.00 min, the rate constant for the reaction is

a. 1.50/min b. 1.05/min c. 4.34/min

d. 0.405/min **e. 0.231/min**

31. (4 pts) The decomposition of HCO_2H (formic acid) follows first-order kinetics.

$$HCO_2H(g) \rightarrow CO_2(g) + H_2(g)$$

The half-life for the reaction at 550°C is 24 s. How many seconds are needed for formic acid, initially 0.82 M, to decrease to 0.018 M?

a. 1.3 E2 s b. 1.1 E3 s c. 2.9 E3 s

d. 7.4 E3 s e. 9.0 E4 s

32. (4 pts) A certain second order reaction has a half-life of 18 seconds when the initial concentration of the reactant is 0.71 M. What is the reaction rate constant in L/mol•s for the reaction?

a. 0.078 b. 0.038 c. 0.020 d. 1.3

33. (3 pts) Given the following mechanism, which species below may be classified as intermediates in the formation of XO_2 from X and O_2?

$$X + YO_2 \rightarrow XO + YO$$

$$XO + YO_2 \rightarrow XO_2 + YO$$

$$YO + O_2 \rightarrow YO_2 + O$$

$$YO + O \rightarrow YO_2$$

a. O only b. YO only c. both XO and YO_2

d. XO, O and YO e. both YO_2 and O_2

34. (3 pts) For the elementary reaction $NO_3 + CO \rightarrow NO_2 + CO_2$,

a. the molecularity is 2 and rate = $k[NO_3][CO]$
b. the molecularity is 4 and rate = $k[NO_3][CO][NO_2][CO_2]$

c. the molecularity is 2 and rate = $k[NO_3][CO]/[NO_2][CO_2]$

d. the molecularity is 4 and rate = $k[NO_3][CO][NO_2][CO_2]$

35. (4 pts) A possible mechanism for the reaction $Br_2 + 2NO \rightarrow 2NOBr$ is shown below. What is the correct form of the rate law for the proposed mechanism?

$$2NO \underset{k_{-1}}{\overset{k_1}{\leftrightarrow}} N_2O_2 \qquad \text{fast, equilibrium}$$

$$N_2O_2 + Br_2 \xrightarrow{k_2} 2NOBr \qquad \text{slow}$$

a. rate = $k_1[NO]^{0.5}$ b. rate = $k_1[Br_2]^{0.5}$ **c. rate = $(k_2k_1/k_{-1})[NO]^2[Br_2]$**

d. rate = $(k_1/k_{-1})^2[NO]^2$ e. rate = $(k_2k_1/k_{-1})[NO][Br_2]^2$

36. (3 pts) For the following reaction conditions, where ΔE is the difference in energy between the reactants and products and the frequency factor (A) is the same for all reactions and the temperature is constant, which reaction will have the greatest rate?

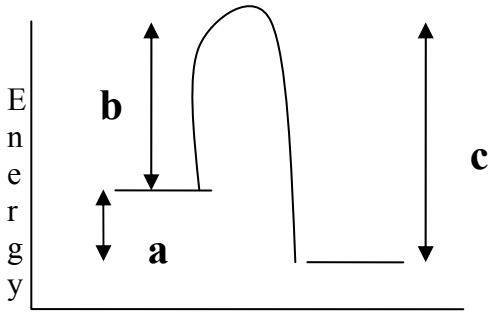
a. Rxn 1: ΔE = + 10kJ/mol and E_a = 25 kJ/mol

b. **Rxn 2: ΔE = + 10kJ/mol and E_a = 11 kJ/mol**
c. Rxn 3: ΔE = – 10kJ/mol and E_a = 25 kJ/mol

d. Rxn 4: ΔE = – 10kJ/mol and E_a = 50 kJ/mol

e. Rxn 5: ΔE = + 25kJ/mol and E_a = 25 kJ/mol

37. (3 pts) Adding a catalyst will NOT change the magnitude of which energy change in the following figure.



a. a only

b. b only

c. c only

d. both a and b

e. both b and c