Instructions

1) Do NOT wait to complete this practice exam until the night before the actual exam!

2) Look over the practice exam before you finish studying so you can see the **type** of questions that you will be asked, and so you know the **format** and **length** of the exam.

3) Do NOT waste your time memorizing the answers to these problems!

- The problems on the real exam will be different
- Look at the end of the course syllabus. There is an outline of the course material. *Any course material on the syllabus is fair game for the real exam even if it does not appear on this practice exam.*

4) Check your work with the answer key (posted as a separate file). The answer key includes detailed calculations.

The answer key will be posted once all sections have a course evaluation completion rate ≥ 60%.

THERE IS AN EQUATION SHEET, A TABLE OF ELECTRONEGATIVITY VALUES, AND A PERIODIC TABLE AT THE END OF THE PRACTICE EXAM.

YOU WILL GET THE SAME INFORMATION ON THE REAL EXAM.

Problems #1-4 will refer to this chemical equation:

$$NH_4CO_2NH_2\ (s) \rightleftharpoons\ NH_3\ (g) + \ CO_2\ (g)$$

Balance the equation, then answer the questions.

1. Which of the following statements are TRUE about the decomposition reaction of ammonium carbamate to produce ammonia and carbon dioxide?

I. All of the compounds in this reaction are polar.
II. The reactant is a covalent crystal.
III. If the pressure were decreased, the equilibrium would shift to the right.
IV. None of the compounds in this reaction contain pi bonds.
V. $\Delta S > 0$ for this reaction.

A) I, II, and IV
B) I, II, and III
C) III and V
D) IV and V
E) I and III

2. This reaction has reached equilibrium at 40.0 ^{o}C, and the total pressure is measured to be 0.363 atm. What is the equilibrium partial pressure of NH_3?

A) 0.405 atm
B) 0.121 atm
C) 0.182 atm
D) 0.726 atm
E) 0.242 atm

3. What is K_p for this reaction at 40.0 ^{o}C?

A) $2.93\ x\ 10^{-2}$
B) $7.09\ x\ 10^{-3}$
C) $3.54\ x\ 10^{-3}$
D) $1.77\ x\ 10^{-3}$
E) 141

4. The volume of the reaction vessel is 3.00 L and T = 40.0 ^{o}C. Use the equilibrium partial pressure of one of the products to determine how many grams of $NH_4CO_2NH_2$ have reacted. The molar mass of ammonium carbamate is 78.08 g/mol.

A) 0.907 g
B) 1.10 g
C) $1.79\ x\ 10^{-6}$ g
D) 8.63 g
E) 2.20 g

Problems #5 – 8 will refer to this chemical equation:

$$C_5H_{12}\ (l) + \ O_2\ (g) \rightarrow \ H_2O\ (g) + \ CO_2\ (g)$$

Balance the equation, then answer the questions.

5. How many moles of O_2 are needed for complete combustion of 0.500 L of pentane (d = 0.630 g/mL)?

A) 4.37
B) 559
C) 315
D) 0.55
E) 34.9

6. Considering that air is 22% by volume O_2, how many liters of air are needed for complete combustion of 0.500 L of pentane (C_5H_{12}) at T = 25 ^{o}C, P = 1.00 atm?

A) 855 L
B) 188 L
C) 1.54 L
D) 3900 L
E) 35 L

7. $\Delta H_{rxn} < 0$ and $\Delta S_{rxn} > 0$. This tells us that:

I. Heat is transferred from the reaction into the surroundings.
II. The reaction is endothermic.
III. This reaction is spontaneous at low temperatures only.
IV. This reaction is spontaneous at any temperature.
V. The products have more microstates than the reactants.

A) II and III
B) I, II, and IV
C) IV and V
D) III only
E) I, IV, and V

8. Which of the following statements is TRUE?

A) All of the carbon atoms in pentane have double bonds.
B) The molecular shape of carbon dioxide is linear.
C) The molecules in liquid pentane (C_5H_{12}) are held together by hydrogen bonding..
D) The bond angle in the water molecule is 180^o.
E) None of these statements are true.

Problems #9 – 10 will refer to this chemical equation:

$$Mg(OH)_2\ (aq) + HCl\ (aq) \rightarrow H_2O\ (l) + MgCl_2\ (aq)$$

Balance the equation, then answer the questions.

9. A chemist combined 10.0 mL of a 0.30 M solution of magnesium hydroxide with 15.0 mL of a 0.30 M solution of hydrochloric acid. Which is the limiting reactant?

A) Magnesium hydroxide
B) Hydrochloric acid
C) Neither
D) Both
E) This cannot be determined from the information provided.

10. This reaction is an acid-base neutralization reaction. At the end of the reaction, the solution should be neutral. However, this is only the case if appropriate amounts of acid and base are combined. What is the approximate pH of the solution at the end of the reaction of 10.0 mL of 0.30 M $Mg(OH)_2$ and 15.0 mL of 0.30 M HCl?

A) 12.78
B) 7.00
C) 1.22
D) 12.47
E) 1.53

There's a lot of space here because this problem requires a lot of work!

Problems #11 – 12 will refer to this balanced chemical equation:

$$CO\ (g) + 2\ H_2\ (g) \rightleftharpoons\ CH_3OH\ (g) \qquad \Delta H^o = -18.0\ kJ/mol$$

11. Which of the following changes would <u>increase</u> the amount of CH_3OH present at equilibrium?

A) Increase the temperature.
B) Remove H_2 from the reaction mixture
C) Add more carbon monoxide
D) Increase the volume of the reaction vessel
E) None of these changes could increase the amount of CH_3OH present

12. Draw the Lewis Structure of methanol (CH_3OH). Use your structure to determine which of the following statements is true.

A) This molecule contains 5 sigma bonds, 0 pi bonds, and 4 lone pairs.
B) This molecule contains 4 sigma bonds, 1 pi bonds, and 0 lone pairs.
C) This molecule contains 5 sigma bonds, 0 pi bonds, and 2 lone pairs.
D) This molecule contains 3 sigma bonds, 3 pi bonds, and 3 lone pairs.
E) This molecule contains 6 sigma bonds, 2 pi bonds, and 4 lone pairs.

Problems #13 – 15 will refer to this chemical equation:

$$ZnS\ (s) + \ O_2\ (g) \rightarrow\ ZnO\ (s) + \ SO_2\ (g)$$

Balance the equation, then answer the questions.

Thermodynamic data at P = 1 atm, T = 25°C.

Substance	ΔH_f (kJ/mol)	S (J/mol•K)	ΔG_f (kJ/mol)
ZnS (s)	−202.9	57.7	−198.3
ZnO (s)	−348.0	43.9	−318.2
O_2 (g)	0	205.0	0
SO_2 (g)	−296.4	248.5	−300.4

13. Which of the following statements are TRUE about this reaction?

I. $\Delta H_{rxn} = -883.0$ kJ/mol
II. $\Delta S_{rxn} = 1139.6$ J/mol•K
III. $\Delta G_{rxn} = -840.6$ kJ/mol
IV. This reaction is spontaneous at 25 °C.

A) I, II, III and IV
B) I and II
C) I only
D) I, III, and IV
E) IV only

14. How much heat is released when this reaction is carried out with 7.0 g of zinc sulfide?
    A) 64 kJ
    B) 32 kJ
    C) 883 kJ
    D) 6200 kJ
    E) No heat is released.

15. In which of the following reactions would $\Delta H_{rxn} = \Delta H_f$ for zinc oxide?

    A) $S_8\,(s) + 8\,O_2\,(g) \rightarrow 8\,SO_2\,(g)$
    B) $Zn\,(s) + \frac{1}{2}O_2\,(g) \rightarrow ZnO\,(s)$
    C) $Zn\,(s) + H_2O\,(l) \rightarrow ZnO\,(s) + H_2\,(g)$
    D) $Zn\,(s) + O\,(g) \rightarrow ZnO\,(s)$
    E) $2\,ZnO\,(s) \rightarrow 2\,Zn\,(s) + O_2(g)$

Problems #16 – 18 will refer to this chemical equation:

$$HF\,(aq) \rightleftharpoons H^+\,(aq) + F^-\,(aq) \qquad K_a = 7.1 \times 10^{-4} \text{ at } 25\,^\circ C$$

16. What is the pH of a 0.010 M solution of hydrofluoric acid?

    A) 2.00
    B) − 1.06
    C) 2.57
    D) 8.83
    E) 2.63

17. Which of the following statements are TRUE about the fluoride anion?
    I. The fluoride anion is larger than a neutral fluorine atom.
    II. The fluoride anion is a neon atom.
    III. The fluoride anion is isoelectronic with a helium atom.
    IV. The fluoride anion contains 6 electrons with the quantum numbers n = 2 and l = 1.

A) I and IV
B) II only
C) I and III
D) I, II, III, and IV
E) IV only

18. Which of the following statements are TRUE about the HF molecule?

I. This molecule does NOT have a permanent molecular dipole.
II. The only intermolecular force present in a sample of liquid HF is dispersion.
III. This molecule has a permanent molecular dipole.
IV. This molecule has one sigma bond and one pi bond.
V. This molecule has a bent shape.

A) I and II
B) II and III
C) III only
D) IV and V
E) V only

19. An aqueous solution of <u>hydrochloric acid</u> has pH = 2.00. What is the concentration of H^+ in this solution?

A) This cannot be determined from the information provided.
B) 0.0023 M
C) 0.13 M
D) 100 M
E) 0.010 M

Problems #20-22 will refer to this chemical equation:

$$Al\,(s) + \ CuCl_2\,(aq) \rightarrow \ AlCl_3\,(aq) + \ Cu\,(s)$$

Balance the equation, then answer the questions.

20. Which of the following statements are TRUE about this reaction?

I. Aluminum is the oxidizing agent.
II. Aluminum is being oxidized.
III. The electron configuration of the copper cation is [Ar] $3d^{10}$
IV. The aluminum cation is smaller than the neutral aluminum atom.

A) I and III
B) II, III, and IV
C) I, II and III
D) II and IV
E) I and II

21. What is the theoretical yield of copper in the reaction of 1.76 g of aluminum with 25 mL of a 0.50 M solution of copper(II) chloride?

A) 6.2 g
B) 4.1 g
C) 12.5 g
D) 0.79 g
E) 64 g

22. Which substances will be present after the reaction of 1.76 g of aluminum with 25 mL of a 0.50 M solution of copper(II) chloride?

$$Al\,(s) + \ CuCl_2\,(aq) \rightarrow \ AlCl_3\,(aq) + \ Cu\,(s)$$

I. Solid aluminum
II. Solid copper
III. Cu^{2+} ions in solution
IV. Cl^{-} ions in solution
V. Al^{3+} ions in solution
VI. Solid $AlCl_3$

A) II, IV, and V
B) I, III, and IV
C) I, II, IV, and V
D) I, II, and VI
E) III, IV, and V

Problems #23-25 will refer to this thermochemical equation:

$$CH_3CH_2OCH_2CH_3\ (l) \rightleftharpoons CH_3CH_2OCH_2CH_3\ (g) \qquad \Delta H_{vap} = 26.0\ kJ/mol$$

23. The vapor pressure of diethyl ether ($CH_3CH_2OCH_2CH_3$) is 0.528 atm at 18 ^oC. What is the vapor pressure of diethyl ether at 35 ^oC?

A) 84.9 atm
B) 0.746 atm
C) 0.955 atm
D) 1.37 atm
E) 0.291 atm

24. The normal boiling point of diethyl ether ($CH_3CH_2OCH_2CH_3$) is:

A) Below 18 ℃
B) Slightly above 35 ℃
C) Between 18 ℃ and 35 ℃
D) 100 ℃
E) 0 ℃

25. When a sample of diethyl ether ($CH_3CH_2OCH_2CH_3$)) is vaporized, which intermolecular forces must be overcome?

I. Dispersion
II. Dipole-dipole
III. Hydrogen bonding
IV. Ion-dipole

A) III and IV
B) I, II, and III
C) I only
D) III only
E) I and II

Problems #26 and #27 refer to this chemical reaction:

$$Pb(NO_3)_2\ (aq) + \ KI\ (aq) \rightarrow$$

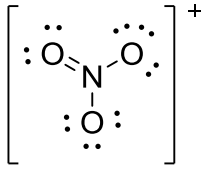
26. The products of this reaction are:

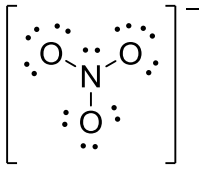
A) Solid lead(II) iodide and aqueous potassium nitrate
B) Aqueous lead(II) iodide and solid potassium nitrate
C) Solid lead(I) iodide and aqueous potassium nitrate
D) Solid lead potassium and aqueous iodide nitrate
E) Aqueous lead(I) iodide and aqueous potassium nitrate

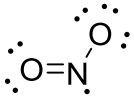
27. What is the electron configuration of the lead ion in the reactant?

A) [Xe] $6s^2\ 4f^{14}\ 5d^{10}\ 6p^2$
B) [Xe] $6s^2\ \ 5d^{10}$
C) [Kr] $5d^{10}\ 6p^2$
D) [Ne] $3s^2\ 3p^6$
E) [Xe] $6s^2\ 4f^{14}\ 5d^{10}$

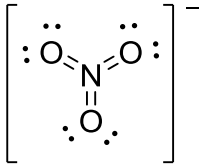
28. Which of these is the correct Lewis structure for **nitrate**?

A) 

D) 

B) 

E) NONE of these are correct.

C) 

Problems #29-30 will refer to this chemical equation:

$$S_8\,(s) + \ F_2\,(g) \rightarrow \ SF_6\,(g) \qquad \Delta H_{rxn} = -1209\ kJ/mol$$

First, balance the equation, then answer the questions.

29. Which of the following statements are TRUE about sulfur hexafluoride?

I. The molecular shape is trigonal bipyramidal.
II. This compound is non-polar.
III. In a liquid sample of SF_6, the molecules are held together with dipole-dipole forces.
IV. The sulfur atom has an expanded octet.
V. The F-S-F bond angles are all 120^o.

A) II and IV
B) I and IV
C) I, II, and V
D) II and V
E) IV only

30. What is the enthalpy change for the decomposition of 1.000 mol of SF_6 to produce F_2 and S_8?

A) None of these answers are correct.
B) – 1209 kJ
C) – 50.38 kJ
D) 1209 kJ
E) 151.1 kJ

31. A sample of an unidentified compound was found to be 74.8% fluorine by mass and 25.2% sulfur by mass. Other experiments showed that the molar mass of the compound is 254.0 g/mol. What is the formula of this compound?

A) S_5F_5
B) SF_5
C) S_2F_{10}
D) SF_3
E) None of these answers are correct.

Problems #32 – 34 will refer to the following information:

Compound A and compound B are in equilibrium.

$$A\ (g) \rightleftharpoons 2\ B\ (g)$$

The equilibrium concentrations of A and B were measured at three temperatures.

Temp. (℃)	[A](M)	[B] (M)
200	0.0125	0.843
300	0.171	0.764
400	0.250	0.724

32. What is K_c for this reaction at 300 ℃?

A) 4.47
B) 3.41
C) 56.9
D) 2.10
E) 2.93×10^{-1}

33. Which of the following statements are TRUE about this reaction?

I. This reaction is endothermic
II. The product side of this reaction is favored.
III. $\Delta H_{rxn} < 0$
IV. At $t = 450$ ℃, $[A]_{equilibrium} > 0.250$ M
V. The concentrations of A and B are equal when the reaction is at equilibrium.

A) I only
B) I, II, and III
C) IV and V
D) II, III, and IV
E) V only

34. How would the position of the equilibrium shift if the size of the reaction vessel was doubled, while holding the temperature constant?

A) It would shift towards the product side
B) It would shift towards the reactant side
C) The position of the equilibrium would stay the same
D) The value of K_c would double
E) This cannot be determined from the information provided

Equation Sheet TEAR THIS PAGE OFF OF YOUR EXAM

$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ % yield = $\frac{\text{isolated yield}}{\text{theoretical yield}}$ x 100% $M_1V_1 = M_2V_2$

$ax^2 + bx + c = 0$ $P_1V_1 = P_2V_2$ 101.33 J = 1 L·atm

molarity (M) = $\frac{moles\ of\ solute}{liters\ of\ solution}$ 0.00 °C = 273.15 K $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $R = 8.314\ \frac{J}{mol\ K}$ $R = 0.0821\ \frac{L\ atm}{mol\ K}$

PV = nRT $d = \frac{PM}{RT}$ $X_i = \frac{n_i}{n_T}$

1 atm = 760 mmHg = 760 torr $\Delta U = q + w$ $w = -P\Delta V$

$H = U + P\Delta V$ $\Delta H = \Delta U + P\Delta V$ $\Delta U = \Delta H - RT\Delta n$

C = ms $q = ms\Delta t$ $q = C\Delta t$

$\Delta H^o_{rxn} = \sum n\ \Delta H^o_f$ (products) $- \sum m\ \Delta H^o_f$ (reactants) $Z_{eff} = Z - \sigma$

$\ln P = -\frac{\Delta H_{vap}}{RT} + C$ $\ln \frac{P_1}{P_2} = \frac{\Delta H_{vap}}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right)$ $\Delta H_{sub} = \Delta H_{fus} + \Delta H_{vap}$

$P_1 = X_1 P_1^o$ $K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ $K_p = K_c\ (0.0821\ T)^{\Delta n}$

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ $pH = -\log[H^+]$ pH + pOH = 14.00

$\Delta S_{universe} = \Delta S_{sys} + \Delta S_{surr} > 0$ $\Delta S^o_{rxn} = \sum n\ \Delta S^o$ (products) $- \sum m\ \Delta S^o$ (reactants)

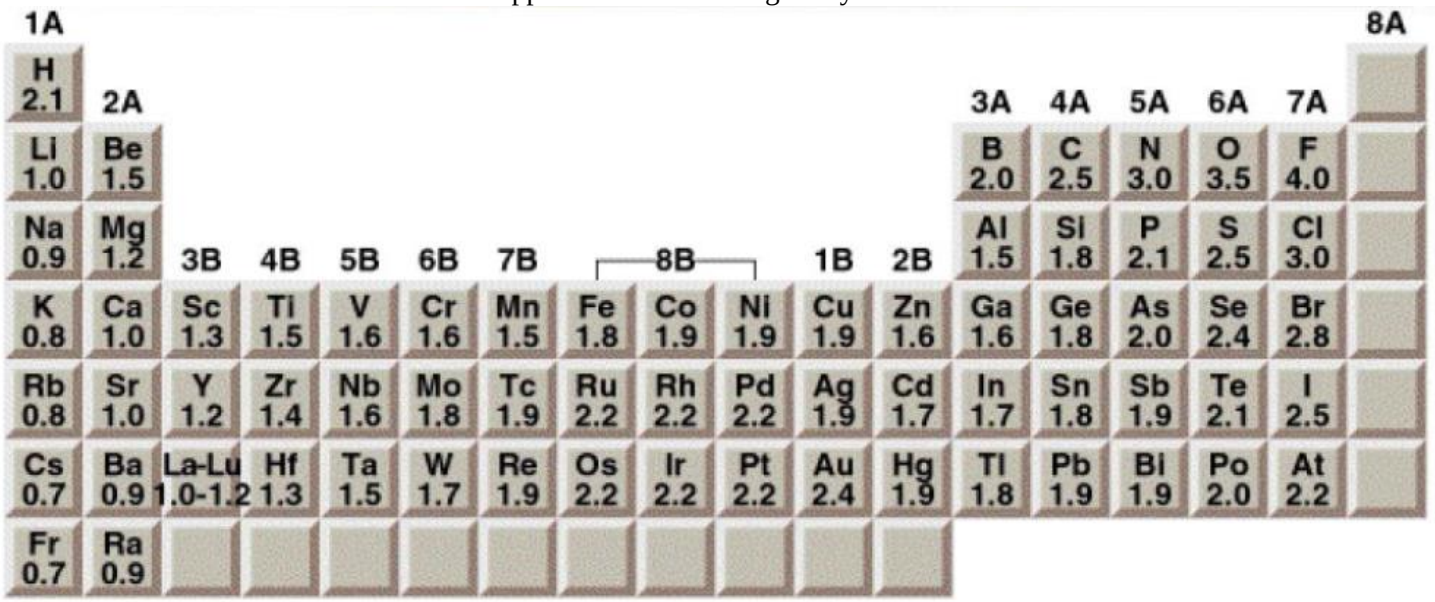
G = H – TS $\Delta G = \Delta H - T\Delta S$ $\Delta G^o_{rxn} = \sum n\ \Delta G^o_f$ (products) $- \sum m\ \Delta G^o_f$ (reactants)

Solubility Rules

Soluble Compounds Containing:	***Insoluble Compounds Containing:***
Alkali metal ions	Carbonates
Halides	Phosphates
Ammonium	Sulfides
Sulfates	Hydroxides
Nitrates	

Exceptions: PbX_2 (lead halides), silver halides, and sulfates of calcium, barium, lead, and silver are insoluble.
Hydroxides of alkali metal ions and barium hydroxide are soluble.
Carbonates, phosphates, and sulfides of alkali metal ions or ammonium are soluble.

Approximate Electronegativity Values



Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 51.99	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57-71	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [208.98]	85 At 209.99	86 Rn 222.02
87 Fr 223.02	88 Ra 226.03	89-103	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [269]	109 Mt [278]	110 Ds [281]	111 Rg [280]	112 Cn [285]	113 Nh [286]	114 Fl [289]	115 Mc [289]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 144.91	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.06	71 Lu 174.97
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 244.06	95 Am 243.06	96 Cm 247.07	97 Bk 247.07	98 Cf 251.08	99 Es [254]	100 Fm 257.10	101 Md 258.1	102 No 259.10	103 Lr [262]

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