Chem 111 2:30p section Final Exam

This exam is composed of 50 questions, 14 of which require mathematics that require a calculator. Go initially through the exam and answer the questions you can answer *quickly*. Then go back and try the ones that are more challenging to you and/or that require calculations.

As discussed in the course syllabus, honesty and integrity are absolute essentials for this class. In fairness to others, dishonest behavior will be dealt with to the full extent of University regulations.

I hereby state that all answers on this exam are my own and that I have neither gained unfairly from others nor have I assisted others in obtaining an unfair advantage on this exam.

_____ …

Signature

$PV = nRT$ $\quad N_o = 6.022x10^{23}\ mol^{-1}$ $E = h\nu = \frac{hc}{\lambda}$ $\quad \overline{u^2} = \frac{3RT}{M}$ $\quad \overline{K.E.} = \frac{1}{2}m\overline{u^2}$ $E_n^{H-atom} = -\frac{R_H hc}{n^2}$ $\quad R_H hc = 1312\ kJ\ mol^{-1}$ $R_H = 1.0974x10^7\ m^{-1}$	$1\ mL = 1\ cm^3$ $1\ atm = 760\ mm\ Hg$ $\Delta H_{vap}(H_2O) = 40.65\ kJ\ mol^{-1}$ $\Delta H_{fus}(H_2O) = 6.00\ kJ\ mol^{-1}$ $d_{water} = 1.00\ g\ mL^{-1}$ $\Delta E = q + w = \Delta H - P\Delta V$	$h = 6.626x10^{-34}\ J\ s$ $c = 2.998x10^8\ m\ s^{-1}$ $R = 0.0820\ L\ atm\ K^{-1}\ mol^{-1}$ $R = 8.314\ J\ K^{-1}\ mol^{-1}$ $J = kg\ m^2\ s^{-2}$

PERIODIC TABLE OF THE ELEMENTS

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.939	4 Be 9.012											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 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	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 95.94	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 181.0	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 Ac 227.0	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

Solubility Rules for some ionic compounds in water

Soluble Ionic Compounds

1. All sodium (Na^+), potassium (K^+), and ammonium (NH_4^+) salts are SOLUBLE.
2. All nitrate (NO_3^-), acetate ($CH_3CO_2^-$), chlorate (ClO_3^-), and perchlorate (ClO_4^-) salts are SOLUBLE.
3. All chloride (Cl^-), bromide (Br^-), and iodide (I^-) salts are SOLUBLE -- EXCEPT those also containing: lead, silver, or mercury (I) (Pb^{2+},Ag^+, Hg^{2+}) which are NOT soluble.
4. All sulfate (SO_4^{2-}) salts are SOLUBLE - - EXCEPT those also containing: calcium, silver, mercury (I), strontium, barium, or lead (Ca^{2+}, Ag^+, Hg_2^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}) which are NOT soluble.

Not Soluble Ionic Compounds

5. Hydroxide (OH^-) and oxide (O^{2-}) compounds are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, or barium (Na^+, K^+, Ba^{2+}) which are soluble.
6. Sulfide (S^{2-}) salts are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, ammonium, or barium (Na^+, K^+, NH_4^+, Ba^{2+}) which are soluble.
7. Carbonate (CO_3^{2-}) and phosphate (PO_4^{3-}) salts are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, or ammonium (Na^+, K^+, NH_4^+), which are soluble.

Some common ions:

PO_4^{3-}	CN^-	$CH_3CO_2^-$	NO_2^-	NO_3^-
CO_3^{2-}	SO_3^{2-}	SO_4^{2-}	CrO_4^{2-}	MnO_4^-

Bond Dissociation Energies (kJ mol^{-1}) (gas phase)

Bond	D	Bond	D	Bond	D
H-H	436	C-C	346	N-N	163
C-H	413	C=C	610	N=N	418
C≡O	1046	C≡N	887	N≡N	945
N-H	391	O-O	146	C-O	358
O-H	463	O=O	498	C=O	745
C-F	485	F-F	155	N-F	283
C-Cl	339	Cl-Cl	242	N-Cl	192
C-I	213	I-I	151	N-I	169

1 In an endothermic process:

1) work is performed on the system
2) heat is transferred to the system
3) work is performed on the surroundings
4) heat is transferred to the surroundings

2 A positive value of ΔE means that:

1) heat is tranferred to the surroundings
2) heat is transfered to the system
3) energy in the form of heat and/or work is transferred to the surroundings
4) energy in the form of heat and/or work is transferred to the system

3 An automobile engine generates **2575** Joules of heat that must be carried away by the cooling system. The internal energy changes by **–3852** Joules in this process.

How much work to push the pistons is available in this process?

1) 4918 J 2) 1095 J 3) 683 J 4) 6283 J 5) 1277 J

4 A 45.5 g sample of copper at 99.8 °C is dropped into a beaker containing 152 g of water at 18.5 °C. When thermal equilibrium is reached, what is the final temperature of the copper? The specific heat capacities of water and copper are 4.184 and 0.385 J g^{-1} K^{-1}, respectively.

1) 25.3 °C 2) 12.5 °C 3) 37.0 °C 4) 90.1 °C 5) 20.7 °C

5 Given the following information:

$2\ N_2O\ (g) + 3\ O_2\ (g) \rightarrow 2\ N_2O_4\ (g)$ $\Delta H° = -145.8$

$2\ N_2O\ (g) \rightarrow 2\ N_2\ (g) + O_2\ (g)$ $\Delta H° = -164.2$ kJ

what is the standard enthalpy change for the reaction:

$N_2\ (g) + 2\ O_2\ (g) \rightarrow N_2O_4\ (g)$ $\Delta H° = ??$ kJ

1) 155 kJ mol^{-1} 2) –146 kJ mol^{-1} 3) 9.2 kJ mol^{-1}

4) 146 kJ mol^{-1} 5) not enough information to determine

6 The root mean square speed of molecules in a sample of He gas is 890 m/s. What is the temperature of the gas?

1) 513 K 2) 890 K 3) 127 K 4) 1208 K 5) 233 K

7 A 2.38 mol sample of He gas is confined in a 62.5 liter container at 62.5 °C. If 2.18 mol of Cl_2 gas is added while maintaining constant temperature, the average kinetic energy per molecule will:

1) decrease 2) remain the same 3) increase

4) not enough information 5) I don't have a clue

8. Which listing below correctly orders the molecules by increasing root mean square molecular speed (slowest → fastest)?

1) $CO_2 < Ar < N_2 < H_2$ 2) $Ar < CO_2 < N_2 < H_2$

3) $H_2 < N_2 < CO_2 < Ar$ 4) $H_2 < N_2 < Ar < CO_2$

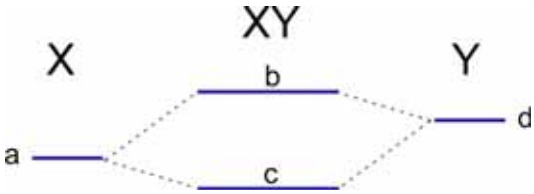
9 A sample of Cl_2 gas is confined in a 2.0 liter container at 50 °C. Then 2.5 mol of He is added, holding both the volume and temperature constant. The pressure will increase because:

1) As the number of molecule-wall collisions increases, the force per collision increases.
2) With more molecules in the container, the molecules have higher average speeds.
3) With more molecules per unit volume, there are more molecules hitting the walls of the container.
4) With higher average speeds, on average the molecules hit the walls of the container with more force.
5) None of the Above

10 What is the average kinetic energy of an N_2 molecule confined in 3.1 L at 1.0 atm and 25°C?

1) 5.71×10^{3} J 2) 9.48×10^{3} J 3) 6.17×10^{-21} J 4) 5.71×10^{-21} J 5) 3.21×10^{-21} J

Consider the molecular orbital energy diagram shown at right.



11 The energy level denoted "**c**" refers to:

1) a nonbonding molecular orbital
2) an antibonding molecular orbital
3) a bonding molecular orbital
4) an atomic orbital

12 The electrons in the orbital represented by energy level "**b**":

1) are distributed more toward X 2) are distributed more toward Y
3) are equally distributed between X and Y

13 The molecule XY is the diatomic $(He\text{-}H)^{+}$. What is its bond order?

1) 0.0 2) 0.5 3) 1.0 4) 1.5 5) 2.0

14. What is the energy of visible light with frequency 4.92×10^{14} Hz?

1) 126 kJ mol^{-1} 2) 196 kJ mol^{-1} 3) 427 kJ mol^{-1} 4) 544 kJ mol^{-1} 5) 832 kJ mol^{-1}

15. Consider two cases for emission from the hydrogen atom:

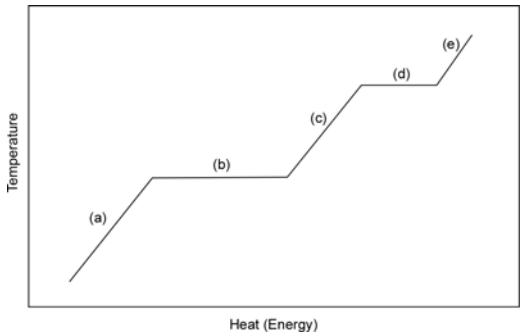
Case 1: Electron goes from n=5 to n=2

Case 2: Electron goes from n=6 to n=4

Compare the energies of the photons emitted:

1) $E_{case\ 1} > E_{case\ 2}$ 2) $E_{case\ 1} < E_{case\ 2}$ 3) $E_{case\ 1} = E_{case\ 2}$

16. Consider the energy vs temperature diagram at right, describing the transitions of water from ice to steam:



The segment labeled (a) is described best with which parameter below:

1) $\Delta H°_{fus}$ 2) $\Delta H°_{vap}$ 3) C_{ice}

4) C_{liquid} 5) C_{steam}

17. The following information is given for water at 1atm:

boiling pt = 100°C $H_{vap}^{100°C,1atm} = 40.7\ kJ\ mol^{-1}$ $C_{liquid\ \text{water}} = 4.18\ J\ g^{-1}\ K^{-1}$

melting pt = 0°C $H_{fus}^{0°C,1atm} = 6.01\ kJ\ mol^{-1}$ $C_{ice} = 2.10\ J\ g^{-1}\ K^{-1}$

At a pressure of 1 atm, what amount of heat is needed to melt a 29.0 g sample of ice at its normal melting point of 0 °C?

1) 4.21 kJ 2) 13.8 kJ 3) 0.561 kJ 4) 9.67 kJ 5) 1.85 kJ

18. At a pressure of 1 atm, what amount of heat is needed to take a 29.0 g sample of ice from –20°C to 25°C?

1) 2.85 kJ 2) 13.9 kJ 3) 32.6 kJ 4) 9.67 kJ 5) 24.3 kJ

19. Which ion has the largest radius?

1) K^+ 2) Ca^{2+} 3) P^{3-} 4) S^{2-} 5) all the same

20. Consider the following samples:

a) 0.531 moles of CH_4 in a 6.18 L container at a temperature of 308K
b) 0.569 moles of CH_4 in a 1.42 L container at a temperature of 453K
c) 0.281 moles of CH_4 in a 2.77 L container at a temperature of 388K
d) 0.212 moles of CH_4 in a 5.95 L container at a temperature of 298K

Which has the highest average molecular speed?

1) a 2) b 3) c 4) d 5) all the same

21. HNO_3 is (data at the front of the exam provide a clue):

1) a strong acid 2) a weak base 3) a weak acid
4) a strong base 5) none of the above

22. Reactions in water that produce gases tend to be:

1) favorable 2) ugly 3) unfavorable
4) endothermic 5) exothermic

23. Which reaction below is a redox reaction?

1) $NaOH\ (aq) + HNO_3\ (aq) \rightarrow NaNO_3\ (aq) + H_2O\ (l)$

2) $Na_2CO_3\ (aq) + 2\ HClO_4\ (aq) \rightarrow CO_2\ (g) + H_2O\ (l) + 2NaClO_4$

3) $CdCl_2\ (aq) + Na_2S\ (aq) \rightarrow CdS\ (s) + 2\ NaCl\ (aq)$

4) $Zn(OH)_2\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + 2\ H_2O\ (l)$

5) None of the above

24. The net ionic equation for the reaction of zinc sulfate and sodium hydroxide is:

1) $Zn^{2+}\ (aq) + 2\ OH^-\ (aq) \rightarrow Zn(OH)_2\ (s) + Na_2SO_4\ (aq)$

2) $ZnSO_4\ (aq) + 2\ NaOH\ (aq) \rightarrow Zn(OH)_2\ (aq) + Na_2SO_4\ (aq)$

3) $Zn^{2+}\ (aq) + 2\ OH^-\ (aq) \rightarrow Zn(OH)_2\ (s)$

4) $Zn^{2+}\ (aq) + 2\ OH^-\ (aq) \rightarrow Zn(OH)_2\ (aq)$

5) No *net* reaction occurs

25. Which element has the highest ionization energy?

1) In 2) Ga 3) Tl 4) B 5) all the same

26. Draw the Lewis structure for **CO^{2-}**. What is the hybridization on carbon?

1) sp^4 2) sp^3 3) sp^2 4) sp 5) sp^3d

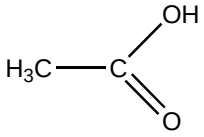
27. Draw the Lewis structure for **$XeOF_4$** (Xe is the central atom). What is the hybridization on **Xe**?

1) sp^3 2) sp^3d 3) sp^3d^2 4) sp^3d^3 5) sp^2

28. The molecule **$XeOF_4$** is:

1) nonpolar 2) polar 3) can't tell

29. The correct molecular formula for the molecule at right is:



1) CO_2H_4 2) $C_2O_2H_4$ 3) $C_2O_2H_3$ 4) C_2OH_4

30. A specific isotope of an ion from a given element has 8 protons, 7 neutrons, and 10 electrons. The ion is:

1) Mn^{3+} 2) N^{3-} 3) P^{3-} 4) Ne^{3-} 5) O^{2-}

31. What is the formula of the ionic compound formed in the reaction of elemental **K** and **F_2**?

1) KF_2 2) KF 3) K_2F_3 4) K_3F_2 5) K_2F

32. What is the (mass) percent composition of **C** in **C_3H_6**?

1) 88.3% 2) 14.4% 3) 50.0% 4) 11.7% 5) 85.6%

33. What is the wavelength of ultraviolet light with frequency 8.57×10^{14} Hz?

1) 209 nm 2) 254 nm 3) 280 nm 4) 190 nm 5) 350 nm

34. What is the maximum number of orbitals that can be identified by the set of quantum numbers n=+6 l=+2 ?

1) 7 2) 6 3) 5 4) 3 5) 2

35. Consider the molecule ClF_2^- How many lone **pairs** are on the central atom?

1) 1 2) 2 3) 3 4) 4 5) 0

36. Light is given off by a sodium or mercury containing street light when the atoms are excited. The light you see arises for which of the following reasons?

1) Electrons are moving from a given energy level to one of higher n
2) Electrons are moving from a given energy level to one of lower n
3) Electrons are being removed from the atom, thereby creating a metal cation

37. Consider the molecule ClF_3 What is the electron pair geometry?

1) Trigonal bipyramidal 2) Octahedral 3) linear
4) Trigonal planer 5) Tetrahedral

38. Which of the following has the highest affinity for electrons?

1) O 2) Se 3) N 4) As 5) P

39. In ionizing elemental sodium to Na^+, from which orbital is an electron removed?

1) 1s 2) 2s 3) 3s 4) 2p 5) 3p

40. In the symmetrical molecule **hydrogen peroxide** HOOH, what is the approximate HOO bond angle?

1) 120° 2) 109° 3) 90° 4) 180° 5) 60°

As we demonstrated in class, reaction of iodine (I_2) and aqueous ammonia (NH_3) produces nitrogen triiodide (NI_3) according to the following reaction:

$$3\ I_2\ (s) + 4\ NH_4OH\ (aq) \rightarrow\ NI_3\ (s) + 3\ NH_4I\ (aq) + 4\ H_2O$$

41 If you completely react 0.678 g of iodine (I_2), what mass of NI_3 can be produced?

1) 0.351 g 2) 0.678 g 3) 0.226 g 4) 0.876 g 5) 0.276 g

42 Nitrogen triiodide (NI_3) is unstable, reacting to form N_2 (g) and I_2 (g), and evolving heat.

$$2\ NI_3\ (s) \rightarrow N_2\ (g) + 3\ I_2\ (g)$$

Spontaneous decomposition of 1.0 g of NI_3 (s) produces what volume of gas at 200°C and 1 atm pressure?

1) 28.7 L 2) 0.731 L 3) 14.4 L 4) 0.098 L 5) 0.197 L

43 Using the Table of Bond Dissociation Energies at the front of the exam, predict ΔH° for the spontaneous decomposition of nitrogen triiodide above.

1) -384 kJ mol^{-1} 2) -927 kJ mol^{-1} 3) -35 kJ mol^{-1}
4) -256 kJ mol^{-1} 5) +927 kJ mol^{-1}

44 What is the molecular geometry of nitrogen triiodide?

1) tetrahedral 2) trigonal planar 3) square planar
4) octahedral 5) trigonal pyramidal

45 What is the hybridization on N in nitrogen trioiodide?

1) sp^4 2) sp^3 3) sp^2 4) sp 5) sp^3d

46 Which do you expect to have the shortest bond length?

1) NI_3 2) NBr_3 3) NCl_3 4) NF_3 5) can't tell

47 In class, we saw the following reaction (unbalanced).

$$Al\ (s) + Br_2\ (l) \rightarrow AlBr_3\ (s)$$

In the correctly balanced reaction, what is the stoichiometry coefficient preceding $AlBr_3$ (all coefficients should be integral)?

1) 1 2) 2 3) 3 4) 4 5) 6

48 In the reaction above of aluminum and bromine, which is the reducing agent?

1) Al (s) 2) Br_2 (l)

49 What is the electron pair geometry in $AlBr_3$?

1) tetrahedral 2) square planar 3) trigonal pyramidal
4) octahedral 5) trigonal planar

50 What is the catalog number for this class?

1) 123 2) 345 3) 111 4) 3.14159 5) 899