

Name _____

Student Number _____

CHEMISTRY 140 FINAL EXAM
December 13, 2011

Numerical answers must be given with appropriate units and significant figures. Please place all answers in the space provided for the question. IF more space is required, write on the back of the question sheet and indicate this in the answer space.

Approximate marks for each question are as indicated in [] brackets. Exact grading may change slightly during the grading procedure.

There are 152 marks available and 180 minutes (3 hours) to complete the exam.

Do not use red ink on the exam. Red ink will not be graded. If you wish to review your multiple choice answers, you must note the answers you gave ON THIS PAPER. We will NOT review the bubble sheets and will not search through them for yours. Be careful filling them out.

PRINT YOUR FULL NAME NEATLY ON THE PAPER NOW.

PRINT YOUR LAST NAME ON THE BACK OF THE LAST PAGE OF THE EXAM

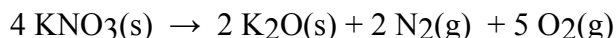
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Multiple Choice	_____ / 102 Marks
Question #1	_____ / 10 Marks
Question #2	_____ / 10 Marks
Question #3	_____ / 10 Marks
Question #4	_____ / 10 Marks
Question #5	_____ / 10 Marks
Total	_____ / 152 Marks

Multiple Choice Section

[2 marks each, 51 questions, total 102 marks]

1) How many moles of oxygen are formed when 58.6 g of KNO_3 decomposes according to the following reaction? The molar mass of KNO_3 is 101.11 g/mol.



- A) 0.290 mol O_2
B) 0.580 mol O_2
C) 18.5 mol O_2
D) 0.724 mol O_2
E) 1.73 mol O_2

2) Which of the following is considered a **STRONG** electrolyte?

- A) NH_4NO_3
B) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
C) PbCl_2
D) $\text{HC}_2\text{H}_3\text{O}_2$
E) CH_3OH

3) What precipitate is most likely formed from a solution containing Ba^{+2} , Na^{+1} , OH^{-1} , and CO_3^{-2} .

- A) NaOH
B) BaCO_3
C) Na_2CO_3
D) $\text{Ba}(\text{OH})_2$

4) Give the **net ionic equation** for the reaction (if any) that occurs when aqueous solutions of Na_2CO_3 and HCl are mixed.

- A) $2 \text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{H}_2\text{CO}_3(\text{s})$
B) $2 \text{Na}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) + 2 \text{H}^+(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow \text{H}_2\text{CO}_3(\text{s}) + 2 \text{NaCl}(\text{aq})$
C) $2 \text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
D) $2 \text{Na}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) + 2 \text{H}^+(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow \text{H}_2\text{CO}_3(\text{s}) + 2 \text{Na}^+(\text{aq}) + 2 \text{Cl}^-(\text{aq})$
E) No reaction occurs.

5) The titration of 25.0 mL of an unknown concentration H_2SO_4 solution requires 83.6 mL of 0.12 M LiOH solution. What is the concentration of the H_2SO_4 solution (in M)?

- A) 0.20 M
B) 0.40 M
C) 0.10 M
D) 0.36 M
E) 0.25 M

6) Determine the oxidation state of Sn in $\text{Sn}(\text{SO}_4)_2$.

- A) +2
B) +4
C) +6
D) 0
E) -2

7) A sample of 0.300 moles of nitrogen occupies 0.600 L. Under the same conditions, what number of moles occupies 1.200 L?

- A) 0.600 moles
B) 1.50 moles
C) 0.33 moles
D) 6.00 moles

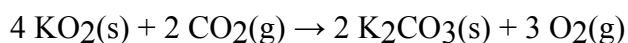
8) Determine the density of NH₃ gas at 435 K and 1.00 atm.

- A) 2.10 g/L
B) 0.477 g/L
C) 0.321 g/L
D) 2.24 g/L
E) 0.851 g/L

9) A mixture of N₂, O₂ and Ar have mole fractions of 0.25, 0.65, and 0.10, respectively. What is the pressure of N₂ if the total pressure of the mixture is 3.9 atm?

- A) 2.5 atm
B) 0.39 atm
C) 0.67 atm
D) 0.98 atm
E) 1.33 atm

10) Determine the theoretical yield and the percent yield if 21.8 g of K₂CO₃ is produced from reacting 27.9 g KO₂ with 29.0 L of CO₂ (at STP). The molar mass of KO₂ = 71.10 g/mol and K₂CO₃ = 138.21 g/mol.



- A) 27.1 g, 80.4 % yield
B) 179 g, 12.2 % yield
C) 91.7 g, 23.8 % yield
D) 206 g, 10.6 % yield
E) 61.0 g, 35.7 % yield

11) Which of the following substances (with specific heat capacity provided) would show the greatest temperature change upon absorbing 100.0 J of heat?

- A) 10.0 g Ag, C_{Ag} = 0.235 J/g°C
B) 10.0 g H₂O, C_{H₂O} = 4.18 J/g°C
C) 10.0 g ethanol, C_{ethanol} = 2.42 J/g°C
D) 10.0 g Fe, C_{Fe} = 0.449 J/g°C
E) 10.0 g Au, C_{Au} = 0.128 J/g°C

12) A balloon is inflated from 0.0100 L to 0.500 L against an external pressure of 10.00 atm. How much work is done in joules? $101.3 \text{ J} = 1 \text{ L} \times \text{atm}$

- A) -49.6 J
 B) 49.6 J
 C) 0.49 J
 D) -0.49 J
 E) -496 J

13) A 4.98 g sample of aniline ($\text{C}_6\text{H}_5\text{NH}_2$, molar mass = 93.13 g/mol) was combusted in a bomb calorimeter with a heat capacity of 4.25 kJ/°C. If the temperature rose from 29.5°C to 69.8°C, determine the value of $\Delta H^\circ_{\text{comb}}$ for aniline.

- A) $+7.81 \times 10^3 \text{ kJ/mol}$
 B) $-3.20 \times 10^3 \text{ kJ/mol}$
 C) $+1.71 \times 10^3 \text{ kJ/mol}$
 D) $-1.71 \times 10^3 \text{ kJ/mol}$
 E) $-7.81 \times 10^3 \text{ kJ/mol}$

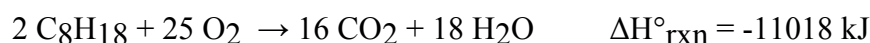
14) Which statement is FALSE?

- A) An exothermic reaction gives heat off heat to the surroundings.
 B) Enthalpy is the sum of a system's internal energy and the product of pressure and volume.
 C) ΔE_{rxn} is a measure of heat.
 D) ΔH_{rxn} is the heat of reaction.
 E) Endothermic has a positive ΔH .

15) Which of the following processes is endothermic?

- A) the freezing of water
 B) the combustion of propane
 C) a hot cup of coffee (system) cools on a countertop
 D) the chemical reaction in a "hot pack" often used to treat sore muscles
 E) the vaporization of rubbing alcohol

16) Using the following equation for the combustion of octane, calculate the heat of reaction for 100.0 g of octane. The molar mass of octane is 114.33 g/mole.



- A) $4.82 \times 10^3 \text{ kJ}$
 B) 4.82 kJ
 C) $9.64 \times 10^3 \text{ kJ}$
 D) $1.26 \times 10^4 \text{ kJ}$

17) Two aqueous solutions are both at room temperature and are then mixed in a coffee cup calorimeter. The reaction causes the temperature of the resulting solution to fall below room temperature. Which of the following statements is TRUE?

- A) The products have a lower potential energy than the reactants.
 B) This type of experiment will provide data to calculate ΔE_{rxn} .
 C) The reaction is exothermic.
 D) Energy is leaving the system during reaction.
 E) None of the above statements are true.

18) A piece of iron (mass = 25.0 g) at 398 K is placed in a styrofoam coffee cup containing 25.0 mL of water at 298 K. Assuming that no heat is lost to the cup or the surroundings, what will the final temperature of the water be? The specific heat capacity of iron = 0.449 J/g°C and water = 4.18 J/g°C.

- A) 348 K
 B) 308 K
 C) 287 K
 D) 325 K
 E) 388 K

19) Choose the reaction that illustrates ΔH°_f for $\text{Ca}(\text{NO}_3)_2$.

- A) $\text{Ca}(\text{s}) + \text{N}_2(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{s})$
 B) $\text{Ca}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq})$
 C) $\text{Ca}(\text{s}) + 2\text{N}(\text{g}) + 6\text{O}(\text{g}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{s})$
 D) $\text{Ca}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq})$
 E) $\text{Ca}(\text{NO}_3)_2(\text{s}) \rightarrow \text{Ca}(\text{s}) + \text{N}_2(\text{g}) + 3\text{O}_2(\text{g})$

20) Place the following types of electromagnetic radiation in order of increasing frequency.

visible light microwaves X-rays

- A) microwaves < visible light < X-rays
 B) X-rays < visible light < microwaves
 C) microwaves < X-rays < visible light
 D) X-rays < microwaves < visible light
 E) visible light < X-rays < microwaves

21) Calculate the wavelength (in nm) of the red light emitted by a neon sign with a frequency of 4.74×10^{14} Hz.

- A) 633 nm
 B) 158 nm
 C) 142 nm
 D) 704 nm
 E) 466 nm

22) Which of the following statements is TRUE?

- A) The emission spectrum of a particular element is always the same and can be used to identify the element.
 B) Part of the Bohr model proposed that electrons in the hydrogen atom are located in "stationary states" or particular orbits around the nucleus.
 C) The uncertainty principle states that we can never know both the exact location and speed of an electron.
 D) An orbital is the volume in which we are most likely to find an electron.
 E) All of the above are true.

29) Which of the following statements is TRUE?

- A) An orbital that penetrates into the region occupied by core electrons is less shielded from nuclear charge than an orbital that does not penetrate and therefore has a lower energy.
- B) An orbital that penetrates into the region occupied by core electrons is more shielded from nuclear charge than an orbital that does not penetrate and therefore has a lower energy.
- C) It is possible for two electrons in the same atom to have identical values for all four quantum numbers.
- D) Two electrons in the same orbital can have the same spin.
- E) None of the above are true.

30) Place the following in order of increasing radius.



- A) $\text{Ca}^{2+} < \text{Cl}^{-} < \text{S}^{2-}$
- B) $\text{Cl}^{-} < \text{Ca}^{2+} < \text{S}^{2-}$
- C) $\text{S}^{2-} < \text{Cl}^{-} < \text{Ca}^{2+}$
- D) $\text{Ca}^{2+} < \text{S}^{2-} < \text{Cl}^{-}$
- E) $\text{Cl}^{-} < \text{S}^{2-} < \text{Ca}^{2+}$

31) Choose the paramagnetic species from below.

- A) Ca
- B) O^{2-}
- C) Cd^{2+}
- D) Zn
- E) Nb^{3+}

32) Choose the ground state electron configuration for Cr^{3+} .

- A) $[\text{Ar}]4s^13d^2$
- B) $[\text{Ar}]$
- C) $[\text{Ar}]4s^23d^6$
- D) $[\text{Ar}]3d^3$
- E) $[\text{Ar}]4s^23d^1$

33) Of the following, which element has the highest first ionization energy?

- A) beryllium
- B) boron
- C) carbon
- D) lithium

34) Which of the following statements is TRUE?

- A) A covalent bond is formed through the transfer of electrons from one atom to another.
- B) A pair of electrons involved in a covalent bond are sometimes referred to as "lone pairs."
- C) It is not possible for two atoms to share more than two electrons.
- D) Single bonds are shorter than double bonds.
- E) A covalent bond has a lower potential energy than the two separate atoms.

42) Determine the electron geometry (eg) and molecular geometry (mg) of BCl_3 .

- A) eg=trigonal planar, mg=trigonal planar
- B) eg=tetrahedral, mg=trigonal planar
- C) eg=tetrahedral, mg=trigonal pyramidal
- D) eg=trigonal planar, mg=bent
- E) eg=trigonal bipyramidal, mg= trigonal bipyramidal

43) How many of the following molecules are polar?



- A) 1
- B) 2
- C) 3
- D) 4
- E) 0

44) A molecule containing a central atom with sp^3 hybridization has a(n) _____ electron geometry.

- A) linear
- B) trigonal bipyramidal
- C) octahedral
- D) tetrahedral
- E) bent

45) What is the strongest type of intermolecular force present in NH_2CH_3 ?

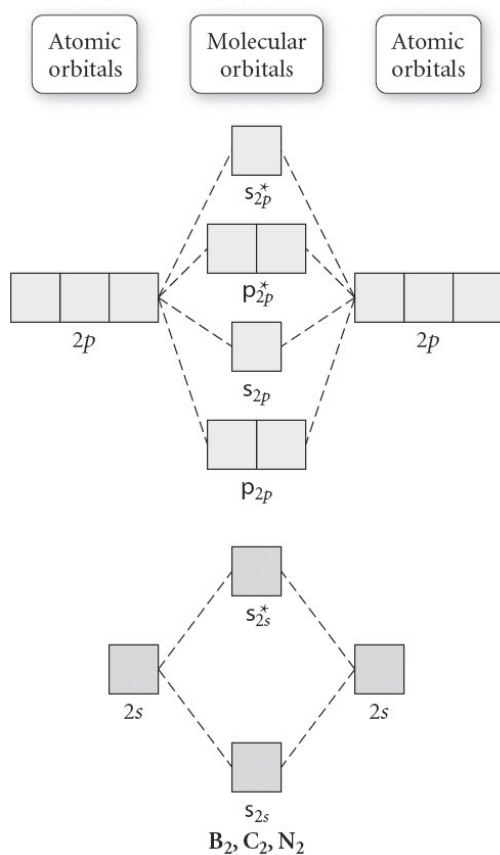
- A) dispersion
- B) dipole-dipole
- C) hydrogen bonding
- D) ion-dipole
- E) none of the above

46) Place the following compounds in order of **increasing** strength of intermolecular forces.



- A) $\text{NH}_2\text{CH}_3 < \text{CO}_2 < \text{F}_2$
- B) $\text{F}_2 < \text{NH}_2\text{CH}_3 < \text{CO}_2$
- C) $\text{NH}_2\text{CH}_3 < \text{F}_2 < \text{CO}_2$
- D) $\text{F}_2 < \text{CO}_2 < \text{NH}_2\text{CH}_3$
- E) $\text{CO}_2 < \text{NH}_2\text{CH}_3 < \text{F}$

47) Use the molecular orbital diagram shown to determine which of the following has the highest bond order.



- A) C_2^{2+}
 B) N_2^{2+}
 C) B_2

- D) C_2^{2-}
 E) B_2^{2+}

48) Which is expected to have the largest dispersion forces?

- A) C_3H_8
 B) $C_{12}H_{26}$

- C) F_2
 D) $BeCl_2$

49) Which of the following substances would you predict to have the highest ΔH_{vap} ?

- A) CH_3Cl
 B) HCl
 C) $HOCH_2CH_2OH$

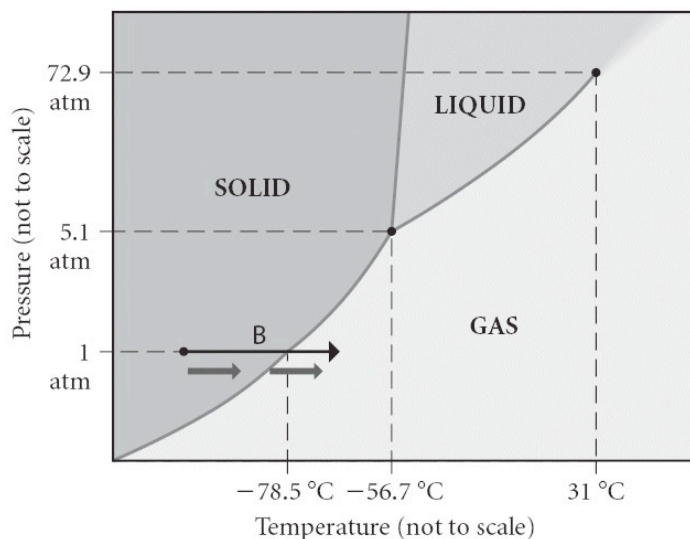
- D) CH_3CH_2OH
 E) $CH_3CH_2CH_2CH_3$

50) How much energy is required to vaporize 98.6 g of ethanol (C_2H_5OH) at its boiling point, if its ΔH_{vap} is 40.5 kJ/mol?

- A) 86.7 kJ
 B) 11.5 kJ
 C) 18.9 kJ

- D) 52.8 kJ
 E) 39.9 kJ

51) Consider the phase diagram shown. Choose the statement below that is TRUE.



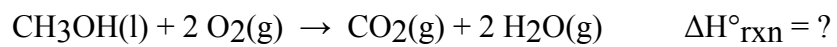
- A) The triple point of this substance occurs at a temperature of 31°C.
- B) At 10 atm of pressure, there is no temperature where the liquid phase of this substance would exist.
- C) The solid phase of this substance is higher in density than the liquid phase.
- D) The line separating the solid and liquid phases represents the ΔH_{vap} .
- E) None of the above are true.

Written Part

- 1) An X-ray photon of wavelength 0.989 nm strikes a surface. The emitted electron has a kinetic energy of 969 eV. What is the binding energy of the electron in kJ/mol?
($KE = \frac{1}{2} mv^2$, 1 electron Volt (eV) = 1.602×10^{-19} J) [10 marks]

2) Use the bond energies provided to estimate $\Delta H^\circ_{\text{rxn}}$ for the reaction below.

[10 marks]



<u>Bond</u>	<u>Bond Energy (kJ/mol)</u>
C-H	414
C-O	360
C=O	799
O=O	498
O-H	464

- 3) Write at least one Lewis structures for the phosphate ion, PO_4^{3-} and write a second structure that is a resonance structure of the first. Identify how many resonance structures you expect in total (it is OK to draw them all if you want, but it is not necessary). On any structures that you do draw, assign formal charges to any atoms that require them. Identify the molecular shape of the phosphate ion and draw the structure in a three dimensional representation. Specify the bond order of the PO bond in phosphate ion.

[10 marks]

- 4) Sketch a heating curve diagram (energy verses temperature) for the warming of ice, initially at -8.00°C , to steam, at a temperature of 120.0°C . Calculate how much heat (in kJ) is required to heat a 15.0 g of ice from 8.00°C to steam at 120°C . The heat capacity of $\text{H}_2\text{O} (s) = 2.09 \text{ J/g}^{\circ}\text{C}$ and $\text{H}_2\text{O} (g) = 2.01 \text{ J/g}^{\circ}\text{C}$. [10 marks]

- 5) Write a hybridization and bonding scheme for acetylene, HCCH, using the valence bond theory approach. Indicate the hybridization about each atom. Sketch the structure, including overlapping orbitals, and label all bonds using clear notation. If the molecule has a molecular dipole indicate this. [10 marks]