Chem 1100a Final Exam

Wednesday, December 12, 2012 3.00 hours

Western Science

SECTION CODE 000 EXAM CODE 111

Message from the Dean: All answer sheets are subject to a common data analysis which identifies anomalies of statistical significance in the selection of right and wrong answers by pairs of students. The course instructor is required to report all statistically significant results which suggest that cheating may have occurred. All such incidents will be subject to further investigation. All proven cases of cheating will be subject to severe academic penalties. If you are currently seated near someone with whom you had studied, and you think you may choose many of the same answers as that person, please raise your hand now and ask a proctor to reseat you.

This exam contains 37 questions, plus 1 bonus question, of equal value. Be sure you have a complete exam paper. "Part marks" will not be awarded.

Scrap paper will not be provided. Use the space under each question to do your work.

The last page contains a periodic table and various equations. It may be removed from this booklet for use.

Place your student ID card on your desk.

The only permitted calculator is a Sharp EL-510R(B). No other electronic devices may be in your possession, even for timekeeping purposes. A molecular model kit is permitted, but the sharing of models or model pieces is strictly forbidden.

Proctors and instructors will not interpret, translate, clarify, or explain questions, nor will they confirm, verify, or assist you with your answers or your thinking. Therefore, you are not permitted to ask any questions related to the content of the exam.

Please note:

The Scantron must be completed within the duration of the exam. At the end of the exam, everyone must put their pencils down. Your materials, whether completed or not, will be collected. Under no circumstances will this booklet be used for marking purposes. The answers on your Scantron are considered to be your official answers, so please ensure that you complete your Scantron accurately. Answers that cannot be read by the Scantron computer will be marked as being incorrect.

If you do not leave before the last 15 minutes, stay in your seat until you are dismissed.

You may keep this question booklet.

Before starting the exam, be sure that you have bubbled in on your Scantron:

- Your student number
- Section code 000
- Exam code 111

1. Manganese(III) fluoride, MnF_3, can be prepared by the reaction of manganese(II) iodide with fluorine:

$$2\ MnI_2 + 13\ F_2 \rightarrow 2\ MnF_3 + 4\ IF_5$$

If the percent yield of MnF_3 prepared by this reaction is always approximately 56%, how many grams of MnF_3 can be expected if 10.0 g of each reactant is used in an experiment?

A) 2.03
B) 1.02
C) 5.60
D) 3.63
E) 6.47

$10g\ MnI_2 = 0.032389713$ $10g\ F_2 = 0.263578944$

$MM_{MnI_2} = 308.74$ $MM_{F_2} = 38$

$\frac{13 F_2}{2 MnI_2} = \frac{x}{0.032389713}$ $x = 0.210533154$ needed F_2

$\therefore F_2$ LR

$\frac{2}{13} = \frac{x}{}$

4. How many mL of pure nitric acid, HNO_3, are needed to react with 2.56 mol of Cu in the following reaction? The density of pure nitric acid is 1.51 g mL^{-1}.

$$3\ Cu + 8\ HNO_3 \rightarrow 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O$$

A) 285

B) 854

C) 430

D) 649

E) 40.1

5. How many of the following electronic transitions could lead to the emission of light from an atom?

- $1s \rightarrow 4p$
- $4p \rightarrow 3d$
- $3d \rightarrow 5f$
- $5f \rightarrow 4d$
- $4d \rightarrow 2p$

A) 4

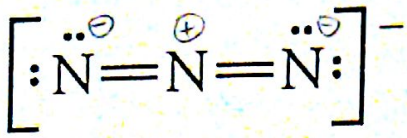
B) 1

C) None of them

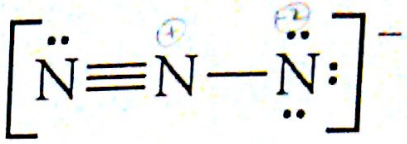
D) 3

E) 2

6. When an air bag in a car inflates, sodium azide (NaN_3) decomposes and yields nitrogen gas that inflates the bag. Consider the following structures of the azide ion, N_3^-. Which is/are the best structures, and which is/are the worst?



1



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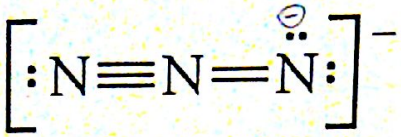

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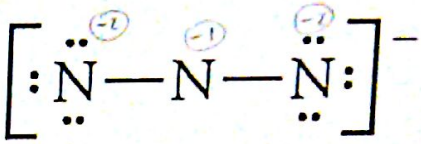


4

	best	worst
A)	3 and 4	1 and 2
B)	1 and 3	2 and 4
C)	3	1 and 2 and 4
D)	1 and 2	3 and 4
E)	1 and 2 and 3	4

7. How many electrons are in *p* orbitals in a ground-state atom of Ge^{3+}?

A) 13

B) 10

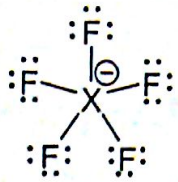
C) 14

D) 11

E) 12

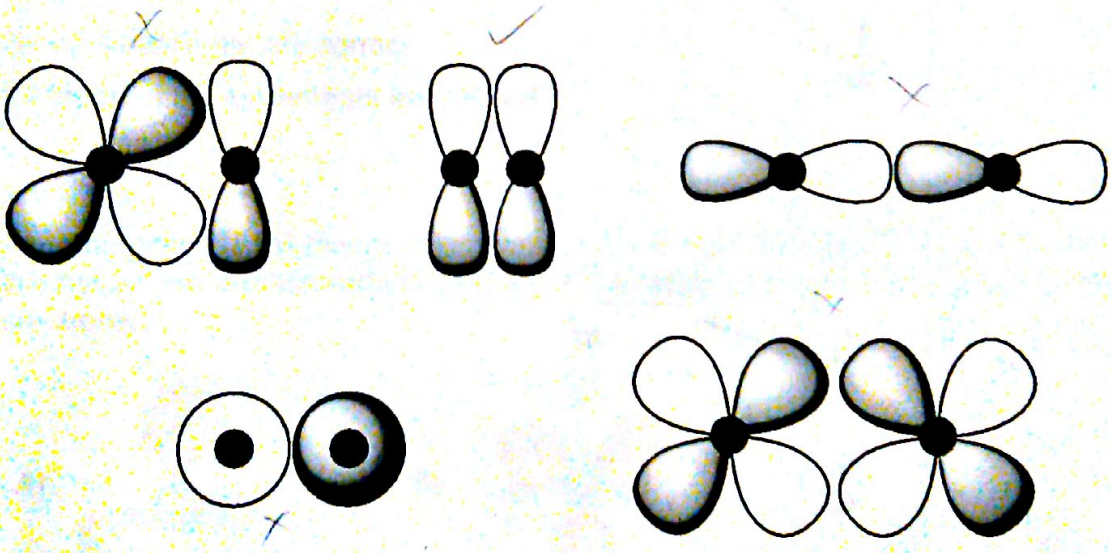
$4s^0$ $3d^{10}$ $4p^1$ $3p^6$ $2p^6$

8. Consider the Lewis structure below. Which one of the following elements could X be?



A) S
B) C
C) Si
D) Cl
E) P

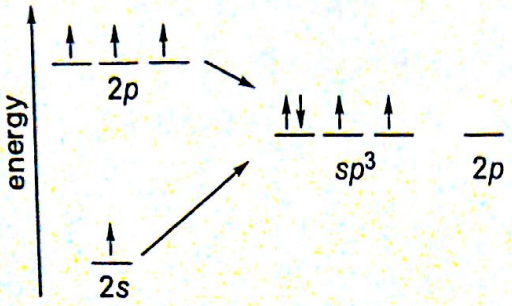
9. How many of the following combinations of atomic orbitals result in the formation of π-type molecular orbitals? (The shaded and white lobes represent opposite phases, while the black circle in the middle represents the nucleus.)



A) 3
B) 4
C) All of them
D) 2
E) 1

10. Which energy diagram correctly shows the formation of sp^3 hybrid orbitals in an atom of carbon just prior to bonding with four hydrogen atoms to make CH_4?

A)



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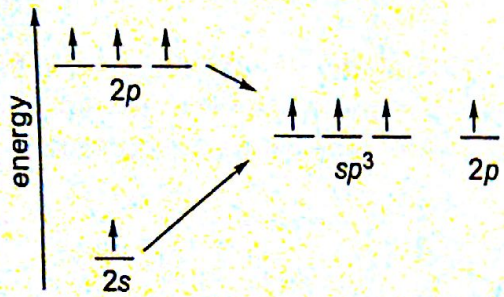
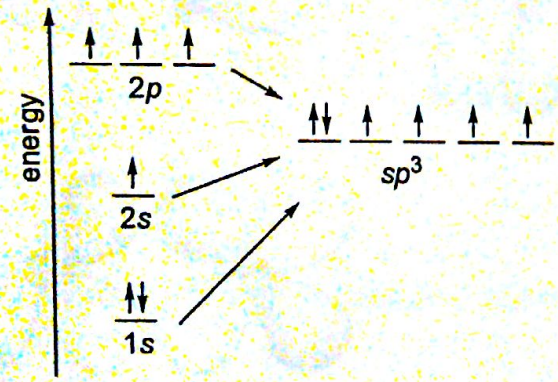
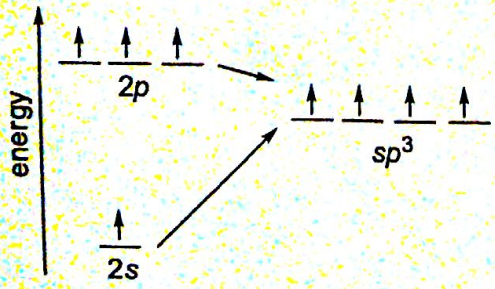


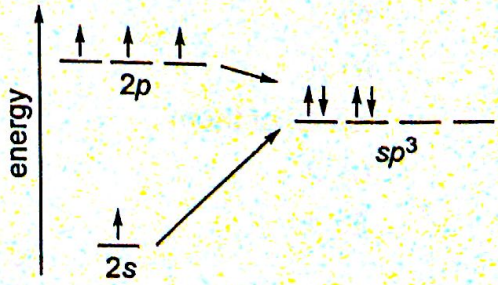
C)



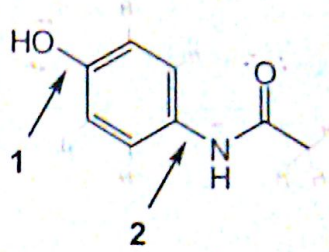
D)



E)



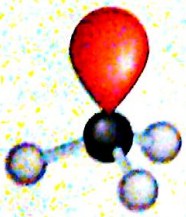
11. Shown on the right is the structure of *acetaminophen*, the active ingredient in Tylenol. How many of the following statements are correct?

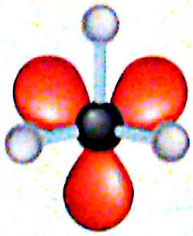


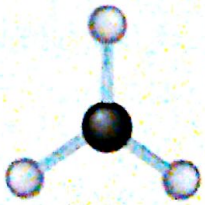
- The bond indicated by arrow #1 is formed by the overlap of sp^2 and sp^3 hybrid orbitals.
- The bond indicated by arrow #2 is more polar than the bond indicated by arrow #1.
- Acetaminophen contains five nonbonding pairs of electrons.
- The molecular formula for acetaminophen contains nine hydrogen atoms.

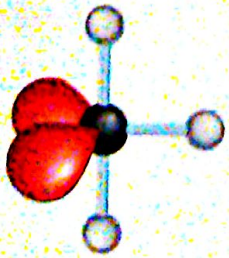
A) 1
B) 3
C) 2
D) All statements are correct
E) None of the statements are correct

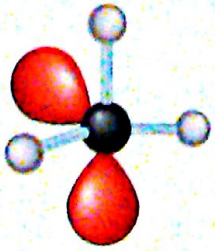
12. According to VSEPR theory, which one of A – E best illustrates the structure of the $AsCl_3^{2-}$ ion? (Each red lobe indicates the location of one nonbonding pair of electrons.)

A)


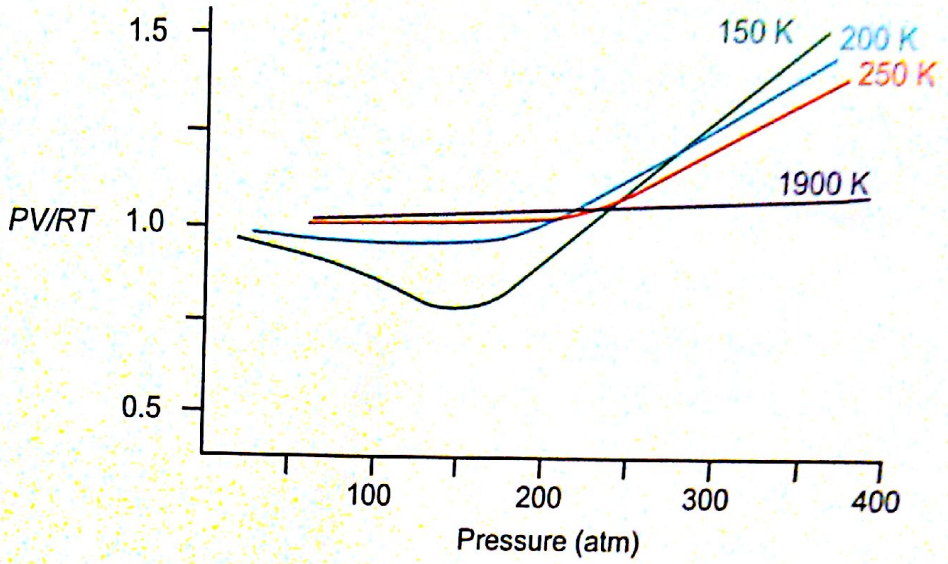
B)


C)


D)


E)


13. Shown below is a plot of *PV/RT* as a function of pressure for one mole of nitrogen gas at four different temperatures. How many of the following statements are correct?



- At 150 K and 150 atm, repulsive interactions dominate.
- At 150 K and 300 atm, attractive interactions dominate.
- Out of the four temperatures, it is at 1900 K that nitrogen deviates the most from ideal behavior over the range of pressures specified.
- Out of the four temperatures, it is at 250 K that nitrogen behaves the most ideally.

A) All of the statements are correct
B) 1
C) 2
D) None of the statements are correct
E) 3

$\frac{PV}{RT} < 1$

14. A sample of an unknown gas with a mass of 3.620 g was decomposed to 2.172 g of O_2 and 1.448 g of S. Before the decomposition, this sample occupied a volume of 1120 mL at 100 kPa and 25.0 °C. What is the molecular formula of the gas?

A) SO_2

B) SO_3

C) $S_{1000}O_{3000}$

D) SO

E) S_2O_3

15. Flask A has a volume of 3.00 L and contains SO_2 at a pressure of 7.50 kPa. Flask B has a volume of 2.00 L and contains excess F_2 at an unknown pressure. Both flasks are at a temperature of 300 K. When the stopcock separating the two flasks is opened, the reaction

$$SO_2(g) + F_2(g) \rightarrow SO_2F_2(g)$$

occurs completely, and the final pressure was found to be 7.50 kPa at 300 K. What was the initial pressure of F_2 in flask B?

A) 4.50 kPa

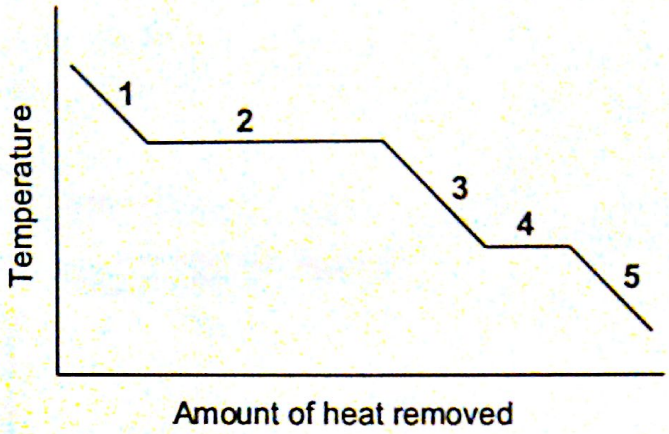
B) 3.00 kPa

C) 18.75 kPa

D) 15.00 kPa

E) 7.50 kPa

16. Shown below is cooling curve for one mole of a substance. The numbers indicate the five portions of the curve. How many of the following statements are correct?



- The temperature of the substance at portion 4 of the curve corresponds to the boiling point of the substance.
- The substance has a larger heat of vapourization than a heat of fusion.
- All three states of the substance have similar specific heat capacities.
- The average kinetic energy of the molecules is changing as the temperature decreases in portion 1 of the graph.

A) None of the statements are correct
B) 3
C) All statements are correct
D) 2
E) 1

17. A substance has a specific heat capacity of 3.28 J g^{-1} K^{-1}. This means that...

A) It takes 32.8 J of heat to warm two grams of the substance by 20 K.
B) At 100 K, one gram of the substance has an internal energy of 328 J.
C) One gram of the substance warms up by 3.28 K when 1 J of energy is added.
D) When one gram of the substance warms up by 10 K, 32.8 J of heat are released.
E) It takes 32.8 J of heat to warm one gram of the substance by 10 °C.

18. Nitric acid neutralizes potassium hydroxide. To determine the heat of reaction, a student placed 55.0 mL of 1.30 M HNO_3 in a coffee cup calorimeter that has a heat capacity of 0.146 kJ $°C^{-1}$, and added 55.0 mL of 1.30 M KOH. All three components were initially at 23.5 °C. The mixture was stirred quickly with a thermometer, and its temperature rose to 29.8 °C. Assuming that the specific heat capacities of all the solutions are 4.184 J g^{-1} $°C^{-1}$, and that all densities are 1.00 g mL^{-1}, calculate the heat of reaction per mole of acid.

A) +53.4 kJ mol^{-1}
B) −26.7 kJ mol^{-1}
C) −40.6 kJ mol^{-1}
D) +26.7 kJ mol^{-1}
E) −53.4 kJ mol^{-1}

19. The heat of vapourization of acetone (58.08 g mol^{-1}), a solvent found in nail polish remover, is 30.3 kJ mol^{-1} at its boiling point. How many kJ of heat would be liberated by the condensation of 5.00 g of acetone at its boiling point?

A) 30.3
B) 9.58
C) 352
D) 151.5
E) 2.61

20. Methane burns with oxygen to produce carbon dioxide and water. The balanced thermochemical equation is shown below. How many grams of methane must be reacted to produce 432 kJ of heat?

$$CH_4(g) + 2\,O_2 \rightarrow CO_2(g) + 2\,H_2O(l)$$

$\Delta H°_f$, in kJ mol^{-1}:

$CH_4(g)$	−74.8
$CO_2(g)$	−393.5
$H_2O(l)$	−285.8

$= -965.1 + 74.8$

A) 33.1
B) 11.4
C) 157
D) 7.76
E) 0.485

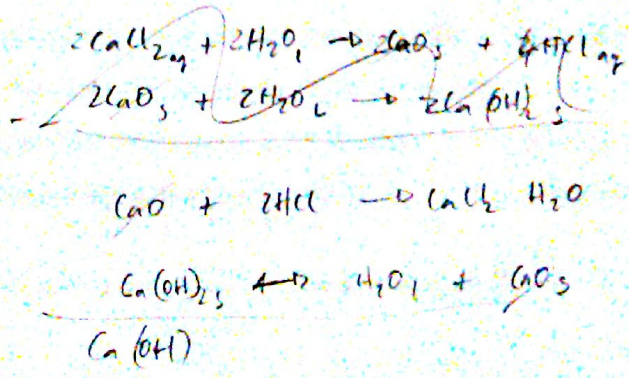
21. Calcium hydroxide reacts with hydrochloric acid by the following equation:

$$Ca(OH)_2(aq) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + 2\,H_2O(l)$$

Determine $\Delta H°$ for that reaction, using the following equations as needed:

$CaO(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$	$\Delta H° = -186$ kJ
$2\,CaO(s) + 2\,H_2O(l) \rightarrow 2\,Ca(OH)_2(s)$	$\Delta H° = -130.2$ kJ
$Ca(OH)_2(s)$ dissolving in water $\rightarrow Ca(OH)_2(aq)$	$\Delta H° = -12.6$ kJ

A) +108 kJ
B) −239 kJ
C) +239 kJ
D) −134 kJ
E) −108 kJ



22. For safety reasons, acids and bases should be stored in separate cabinets in a laboratory. Concentrated hydrochloric acid is 12.0 M, and the molarity of 25% ammonium hydroxide by weight is 13.4 M. Both are sold in 2.5 L bottles. If there were an accident and the two bottles broke and the acid and base mixed, how much heat would evolve?

$$NH_4OH(aq) + HCl(aq) \rightarrow NH_4Cl(aq) + 2\,H_2O(l) \qquad \Delta H^\circ = -50.49\ kJ$$

A) 423 kJ

B) 1515 kJ

C) 0.594 kJ

D) 1691 kJ

E) 1.68 kJ

23. Which one of A – E best describes the First Law of Thermodynamics?

A) When a system is heated at constant volume, the internal energy of the system remains the same.

B) A reaction that has a negative ΔG must be exothermic.

C) Spontaneous mutations occur when nucleobases undergo tautomerism.

D) An object at rest stays at rest, and an object in motion stays in motion, unless an external force is applied.

E) Work and heat are equivalent ways of adding energy to a system.

24. If there is a decrease in the number of moles of gas during an exothermic chemical reaction that is performed at constant pressure, then it can be said that...

A) ΔH is smaller than ΔE because the volume of the system decreases.
B) ΔH is larger than ΔE because the volume of the system decreases.
C) ΔH is larger than ΔE because the volume of the system increases.
D) ΔH is smaller than ΔE because the volume of the system increases.
E) ΔH is identical to ΔE.

25. When 0.6484 g of cetyl palmitate ($C_{32}H_{64}O_2$, 480.83 g mol^{-1}), a fruit wax, was burned in bomb calorimeter with a total heat capacity of 11.99 kJ K^{-1}, the temperature of the calorimeter rose from 24.518 °C to 26.746 °C. Calculate the molar heat of combustion of cetyl palmitate in kJ per mole.

A) 244.8
B) 19810
C) 2448482
D) 19.8
E) 0.03630

26. The standard heat of formation of ethanol vapour, $CH_3CH_2OH(g)$, is -235.5 kJ mol^{-1}. Using the data below, estimate the enthalpy of the C–O bond in ethanol.

Standard heats of formations for gaseous atoms, in kJ mol^{-1}:

H	218
C	717
O	249

Average bond enthalpies, in kJ mol^{-1}:

C–C	348
C–H	412
O–H	463

A) 2635 kJ mol^{-1}

B) -1458 kJ mol^{-1}

C) 329 kJ mol^{-1}

D) 438 kJ mol^{-1}

E) 356 kJ mol^{-1}

27. Which one of A – E is the best example of a nuclear fission reaction?

A) $^{70}Zn + {}^{208}Pb \rightarrow {}^{278}Uub$

B) $6\ CO_2 + 6\ H_2O \rightarrow$ glucose $(C_6H_{12}O_2) + 6\ O_2$

C) $^{51}V + {}^{2}H \rightarrow {}^{53}Cr$

D) $^{209}Po \rightarrow {}^{205}Pb + {}^{4}He$

E) $^{2}H + {}^{3}H \rightarrow {}^{4}He + n$

28. How many of the following processes are entropically favourable?

- $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
- The evaporation of sweat from your skin
- The formation of frost on a car's windshield
- The escape of propane from a freshly filled barbeque tank

A) 3

B) 1

C) 2

D) All are entropically favourable

E) None are entropically favourable

29. Isooctane, an important constituent of gasoline, has a boiling point of 99.3 °C and a heat of vapourization of 37.7 kJ mol^{-1}. What is the ΔS (in J mol^{-1} K^{-1}) for the vapourization of one mole of isooctane?

A) 0.101

B) 0.00

C) 380

D) 101

E) 0.380

$\Delta S = \Delta H$

30. The heat of vapourization of carbon tetrachloride, CCl_4, is 30.0 kJ mol^{-1}. Using the data below, estimate the standard heat of formation of liquid CCl_4.

Standard heats of formation for gaseous atoms, in kJ mol^{-1}:

C	717
Cl	121

Average bond enthalpies, in kJ mol^{-1}:

C–Cl	338

A) −1352 kJ mol^{-1}
B) +151 kJ mol^{-1}
C) −151 kJ mol^{-1}
D) −181 kJ mol^{-1}
E) +181 kJ mol^{-1}

31. The $\Delta H°$ of combustion oxalic acid, $H_2C_2O_4(s)$, is −246.05 kJ mol^{-1}. Using the data below, estimate the $\Delta G°$ for the combustion of one mole of oxalic acid.

$\Delta H°_f$, in kJ mol^{-1}:

$CO_2(g)$	−393.5
$H_2O(l)$	−285.8

$S°$, in J mol^{-1} K^{-1}:

C(s)	5.69
$CO_2(g)$	213.6
$H_2(g)$	130.6
$H_2O(l)$	69.96
$O_2(g)$	205.0
$H_2C_2O_4(s)$	120.1

A) −82106 kJ
B) −164.2 kJ
C) −321.0 kJ
D) −327.9 kJ
E) −908.6 kJ

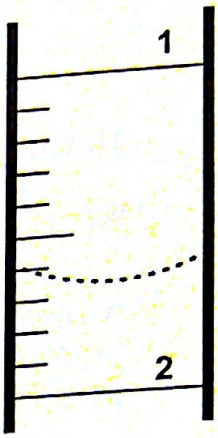
32. Potassium iodide dissolves in water. When potassium iodide dissolves in water, the mixture becomes cool. Which statement is correct?

A) When KI dissolves in water, the water molecules, on average, move faster.
B) The magnitude of $T\Delta S$ for the dissolving of KI in water is greater than the magnitude of ΔH.
C) The dissolving of KI in water is a nonspontaneous process.
D) The dissolving of KI in water is an exothermic process.
E) None of the above

33. Which one of the following best explains *decanting*?

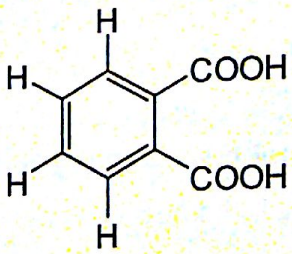
A) To filter a solution by vacuum filtration
B) To pour off a liquid and leave the solid behind
C) To stir and pour quickly into a flask
D) To cool a solution to prevent spattering
E) To crush the solid precipitate with a scoopula

34. A drawing of part of a burette is shown on the right. The meniscus is indicated by the dotted line. Which one of the following is the correct burette reading?



A) 1.66 mL
B) 48.35 mL
C) 2.35 mL
D) 1.7 mL
E) 2.4 mL

35. One mole of phthalic acid, shown below, reacts with how many moles of NaOH?



A) 4
B) None
C) 6
D) 3
E) 2

36. In the system that you had set up for the Molar Volume of Nitrogen experiment, the pressure due to the water vapour was affected by which one of A – E?

A) The volume of nitrogen gas produced
B) The temperature of the nitrogen gas produced
C) The volume of the liquid water
D) The temperature of the liquid water
E) The atmospheric pressure

37. In the Thermodynamics experiment, why was it necessary to clean the thermistor probe before moving it from the acid to the base?

A) The friction from the cleaning warms the probe, thus making it ready for use.
B) The probe does not work if it is wet with acid.
C) The acid on the probe mixes with the base, producing heat.
D) The reaction occurs more slowly when the probe is clean.
E) The residual acid on the probe dissolves the metal coating on the probe.

38. **This question is a bonus question.**

What is required in order to take Chem 1200b?

A) A course grade of 60 in Chem 1100a plus a grade of 50 in any first-year math or calculus course
B) A course grade of 50 in Chem 1100a plus the special permission of the department
C) A course grade of 60 in Chem 1100a
D) A course grade of 50 in Chem 1100a
E) A course grade of 40 in Chem 1100a

Final check... make sure that you have:

- Accurately indicated your answers and student number on the Scantron
- Correctly and completely filled in the Scantron bubbles (see the example on the Scantron) using an HB pencil

End of exam. Solutions will be posted after the end of the December exam period.

Course grades will be released by the Registrar on student.uwo.ca.

Exam and course grades will NOT be posted to OWL.