Name _____ Circle one

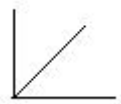
Exam 2 / Chem 120 / Fall 2014 Lab Sec: 11:00AM or 2:30PM

100 Exam pts. (134 raw pts. total): Answer questions #1-30 on scantron. (#1-20=4pts ea; #21-30=2pts ea); answer questions #31-36 on the exam, pt values indicated.

1. Sphagnum moss had been very comfortably growing on the north side of an oak tree for an entire spring until the summer, when the volume of its spore capsule decreased from 8.00 mm^3 to 3.00 mm^3. The capsule burst and launched a vortex with an acceleration of 325,000 m/s^2 that dispersed its spores to a height of 20.0 cm. The air in the capsule was originally @ 760. torr, what was the pressure when the capsule burst?

a) 0.375 atm
b) 1.375 atm
c) 2.66 atm
d) 3.00 atm
e) 8.00 atm

2. Which of the following four graphs is the best general representation of an "ideal" gas plotted with the Volume (L) versus Temperature (^oC) of a 1 mole sample at constant pressure?

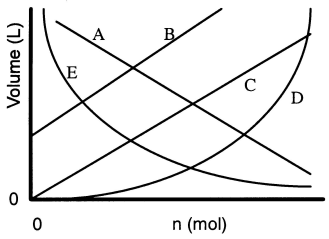
a) 

b) 

c) 

d) 

3. Which of the lines on the figure below is the best representation of Avogadro's Law relating to the behavior of gases? (Volume versus moles; pressure and temperature constant.)



4. The mole % of O_2 in the air we breathe is 20.94% and the mole % of N_2 is 78.08%. The remaining components of air have a total mole % = 0.98%. At a barometric pressure of 760 torr and 37^oC, if the partial pressure of oxygen in every breath you take is 153 mm Hg, and the residual lung capacity is 500 cm^3 what is the volume of O_2 in each breath? (R = 0.0821 L atm mol^{-1} K^{-1})

a. 50 cm^3
b. 100 cm^3
c. 500 cm^3
d. 1,000 cm^3
e. 2,000 cm^3

5. An 11.6 gram sample of an unknown gas experimentally occupies a volume of 4.29 L at 1.00 atm and a temperature of 45.0°C. Identify this gas. (R = 0.0821 L atm mol^{-1} K^{-1})

   a) N_2O b) N_2 c) N_2O_4 d) F_2 e) Cl_2

6. As discussed in class, atropine, $C_{17}H_{23}NO_3$ (MM= 289.37 g/mol), is used as an antidote for nerve agents such as Sarin, $C_4H_{10}FO_2P$ (MM=140.09 g/mol). The Department of Homeland Security has commissioned you to find an antidote to be used in place of atropine in the gas/vapor phase that would diffuse 3x better than atropine. Which of the following molecules would best fit the diffusion criteria?

   a) H_2O_2
   b) $C_6H_{10}NO_3$
   c) $C_4H_{10}N$
   d) $C_9H_{18}N$
   e) N_2H_4

7. A system does work by contracting from an initial volume of 15.0 L to a final volume of 10.0 L under a constant external pressure of 0.800 atm. What is the "PΔV" work, *w*, in Joules?
   $1m^3$ = 1,000L; 1atm = 101,325 Pascal,

$$J = \frac{kg \cdot m^2}{s^2} = N \cdot m = Pa \cdot m^3 = W \cdot s = C \cdot V$$

   a. -810
   b. -4.05
   c. -405
   d. +405
   e. $+8.10 \times 10^2$

8. A system absorbs 21.6 kJ of heat while performing 36.3 kJ of work on the surroundings., what is the value of ΔE_{system}?

   a. +14.7 kJ
   b. -14.7 kJ
   c. +79.9 kJ
   d. -57.9 kJ
   e. +57.9 kJ

9. The reaction of hydrochloric acid with sodium hydroxide releases -56.0 kJ per mole of water produced. If 100.0 mL of 1.25 M NaOH(aq) is reacted with 50.0 mL of 2.00 M HCl(aq). How much energy (calculated) does this reaction produce?

   a. +7.0 kJ
   b. -7.0 kJ
   c. +5.6 kJ
   d. -5.6 kJ
   e. cannot determine without the specific heat of the products

10. A neutralization reaction of nitric acid with potassium hydroxide released -7.0 kJ. If the enthalpy was transferred to 25.0g of water, which was @ 25.0 ^oC, what would be the temperature of the water after the complete heat transfer from the neutralization to the water? (Cp H_2O = 4.184 J/ mol ^oC)
    a) 24.9 ^oC
    b) 53.5 ^oC
    c) 66.9 ^oC
    d) 78.5 ^oC
    e) 91.9 ^oC

11. Dr. Who, a fictional character who is a time traveller and Lord of Gallifrey, entered the atmosphere of a planet in a galaxy far far way, landing his 4.00 x 10^3 kg time vehicle, the Tardis, in a lake with 1.00 x 10^4 gallons of pure water. The Tardis temperature was lowered and the lake gained temperature until they both reached the same temperature. The ΔT of the Tardis was -4.0 ^oC. The ΔT of the lake water was +15 ^oC . What is the specific heat of the Tardis? (1 gallon = 3.785 L; density H_2O = 1.00 g/mL; Cp H_2O = 4.184 J/ mol ^oC)

    a) 0.0100 J/g°C
    b) 0.0390 J/g°C
    c) 1.50 J/g°C
    d) 1.48 x 10^{-1} J/g°C
    e) 3.75 J/g°C

12. Nitric acid, which is among the top 15 chemicals produced in the United States, was first prepared over 1200 years ago by heating naturally occurring sodium nitrate with sulfuric acid and collecting the vapors produced. Calculate $\Delta H°_{rxn}$ for this reaction. $\Delta H°_f$ [$NaNO_3(s)$] = -467.8 kJ/mol; $\Delta H°_f$ [$NaHSO_4(s)$] = -1125.5 kJ/mol; $\Delta H°_f$ [$H_2SO_4(l)$ = -814.0 kJ/mol; $\Delta H°_f$ [$HNO_3(g)$] = -135.1 kJ/mol

    $$NaNO_3(s) + H_2SO_4(l) \rightarrow NaHSO_4(s) + HNO_3(g)$$

    a. -644.2 kJ
    b. -21.2 kJ
    c. 21.2 kJ
    d. 644.2 kJ

13. Calculate the enthalpy change for the reaction:

    $$NO(g) + O(g) \rightarrow NO_2(g)$$

    from the following heats of reaction:

    $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ $\quad \Delta H$ = -198.9 kJ
    $2O_3(g) \rightarrow 3O_2(g)$ $\quad \Delta H$ = -284.6 kJ
    $O_2(g) \rightarrow 2O(g)$ $\quad \Delta H$ = 495.0 kJ

    a. -551.6 kJ
    b. -304.1 kJ
    c. 153.8 kJ
    d. 438.4 kJ
    e. 876.8 kJ

14. List the following types of electromagnetic radiation in order of *decreasing* frequency:

    (i) X rays used for medical purposes
    (ii) Microwave oven
    (iii) green traffic light
    (iv) red traffic light
    (v) ultraviolet light that causes sunburn

    a) i > v > iii > ii > iv
    b) ii > i > iv > > iii > v
    c) i > v > iv > ii > iii
    d) i > ii > v > iv > ii
    e) i > v > iii > iv > ii

15. When a hydrogen electron makes a transition from $n = 4$ to $n = 2$, which of the following statements is *true*?

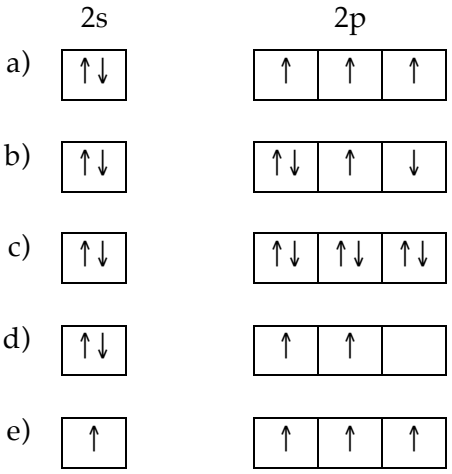
I. Energy is emitted.
II. Energy is absorbed.
III. The electron loses energy.
IV. The electron gains energy.
V. The electron cannot make this transition.

a) I, IV b) I, III c) II, III
d) II, IV e) V

16. Which of the following electron configurations is incorrect?

a) Ge: $[Kr]4s^2 3d^{10} 4p^2$
b) Tc: $[Kr]5s^2 4d^5$
c) Ca: $[Ar]4s^2 3d^{10}$
d) Ag: $[Ar]5s^1 4d^{10}$
e) Bi: $[Xe]6s^2 4f^{14} 5d^{10} 6p^3$

17. Consider the following electron arrangements. Which of the choices represents the ground state for the common ion of a Group 2 alkaline earth?



18. Of the choices below which has an electronic configuration different from the others.

a) Na^{+1} b) O^{+2} c) N^{3-} d) F^- e) All are the same.

19. Consider the following sets of quantum numbers.

	n	l	m_l
Set a	1	0	1
Set b	3	3	0
Set c	2	1	1
Set d	3	2	–2
Set e	3	1	–2
Set f	2	0	0

Of these 6 sets, how many of them are impossible?

a) 2 b) 3 c) 4 d) 5 e) 6

20. How many of the following reactions are oxidation-reduction?

$2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$
$H_2O(l) + SO_3(g) \rightarrow H_2SO_4\ (g)$
$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$
$Fe_2O_3(s) + 3\ H_2SO_4(aq) \rightarrow Fe_2(SO_4)_3(aq) + 3\ H_2O(l)$
$2\ KMnO_4(aq) + 10\ FeSO_4(aq) + 8\ H_2SO_4(aq) \rightarrow$
$K_2SO_4(aq) + 2\ MnSO_4(aq) + 5\ Fe_2(SO_4)_3(aq) + 8\ H_2O(l)$

a. 1 b. 2 c. 3 d. 4 e. 5

End of Multiple Choice

True (A)/ False (B): Answer on Scantron

For the following 3 questions, consider the combustion of ethanol, C_2H_5OH, *@ standard conditions:*

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l),\ \Delta H^o = -1.37 \times 10^3\ kJ$$

21. The enthalpy change would be different if water vapor were produced.
22. The partial pressure of the carbon dioxide produced is larger than the partial pressure of oxygen that reacted for the combustion using 1 mole of ethanol and 3 moles of oxygen.
23. Oxygen can only be the limiting reactant at low *P*, high *T*, and small values for *n (# of moles)*.

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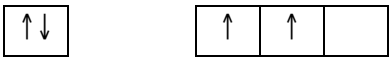
24. The following are correctly ordered by increasing atomic radii: Na+ < Ne < F-
25. The correct quantum numbers for the highest energy electron in the following diagram are: $l = 1$, $m_l = 0$, $m_s = + 1/2$



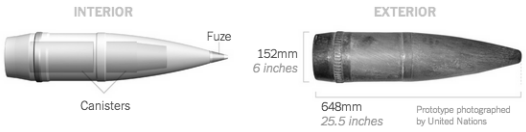
26. The sizes of atoms generally increase progressively from top to bottom in a family in the periodic table and increase progressively from left to right in a period.
27. In an oxidation-reduction reaction the reactant, which is oxidized, looses one or more electrons and its oxidation number decreases. It is the reducing agent.
28. Of the following, only zinc and strontium are diamagnetic.

Cu(s) $Sr^{2+}(aq)$ Zn(s) $Sc^{3+}(aq)$

29. The relative electronegativities of F, Rb, and I increase in the following order: I < Rb < F.
30. Consider the following containers, one with helium at 27°C and the other with argon at 27°C. The rms speed of the He is higher than the Ar atoms and the pressure of the two samples are equal.

End of True/ False

31. [6pts] Mustard agents, chemical weapons that were first used in WWI, were found in artillery shells left behind by Saddam Hussein's army. The type of mustard agent that was found had the following properties reported: molecular formula $C_4H_8Cl_2S$, MM = 159.08 g mol^{-1} ; $density_{liquid}$ = 1.27 g/mL; b.p. 218 °C; Its odor detection limit is 0.6 mg/m^3 of air.



a) Mustard agent gas, 5.25 ml @ 25 °C, was collected over water. [water vapor pressure = 23.76 mmHg, and the barometric pressure = 755 torr.] Show your calculation for the amount of mustard agent in grams that were collected. (R = 0.0821 L atm mol^{-1} K^{-1})

b) If this amount of mustard agent were found in 1 m^3 of pure air, would you be able to detect it? (1m^3 = 10^6 cm^3; 1 cm^3 = 1mL.) Briefly explain.

32. [6pts] Combustion of octane (C_8H_{18}, MM = 114 g/mol) releases 48.0 kJ per gram of octane ($\Delta H_{combustion}$ = -5,470 kJ/mol).

a) Write a balanced chemical equation for the reaction.

Balanced Equation:

→

b) How many grams of sheep fat will have the equivalent combustion energy as 1 gallon of gasoline? (Sheep fat $\Delta H_{combustion}$ = -9.4 kcal/g; 1 gallon = 3.785 L; 1 cal = 4.184 J) Show your calculation.

c) What will be the calculated final temperature of 1000. gallons of water in a hot tub, which was initially @ 18.0 °C, assuming that it absorbed all of the energy released? (Density H_2O = 1.0 g/mL; Specific Heat water = 4.184 $J \cdot g^{-1} \cdot °C^{-1}$) Show your calculation.

33. [6pts] Consider the following enthalpies of reaction:

1) $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$	$\Delta H_1 = -198.9$ kJ
2) $O_3(g) \rightarrow 1\frac{1}{2}\ O_2(g)$	$\Delta H_2 = -142.3$ kJ
3) $O_2(g) \rightarrow 2O(g)$	$\Delta H_3 = 495.0$ kJ

a) Show a completed mathematical formula for the overall enthalpy of reaction for the following reaction, which accounts for one of the NO_x pollutants in automobile exhaust.

$$NO(g) + O(g) \rightarrow NO_2(g)$$

ΔH_{rxn} for the reaction can be calculated from the respective enthalpies above: $\Delta H_1, \Delta H_2, \Delta H_3$:

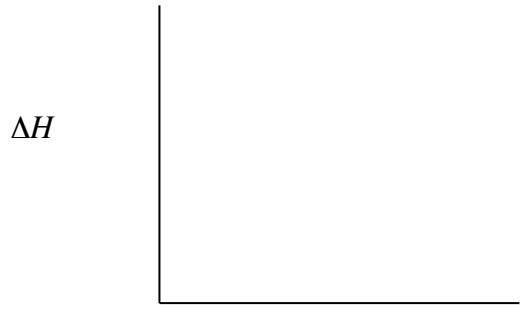
$$\Delta H_{rxn} =$$

b) Calculate the value in kJ for the enthalpy of reaction, ΔH_{rxn}

kJ

c) *(Circle one.)* The reaction is: ***exothermic*** or ***endothermic***.

d) Draw an energy diagram for the reaction, which illustrates your answer.. Clearly show and label the relative ΔH of each of the 3 reactions, the ΔH_{rxn}, and the respective reaction steps 1), 2) and 3) with appropriate arrows.



34. [6pts] Various drugs that inhibit the formation of estrogen are used in the treatment of breast cancer. A recent publication, JACS, 2014 (DOI:101021/JA508185d), has provided "definitive evidence" that one type of drug, aromatase inhibitors, target an enzyme which contains the active iron species in example (I) below rather than (III), which was also a possibility.

a) Provide the correct oxidation number for iron in I and III and the specified element in II and IV

(I) Fe in FeO^{3+} ☐ (II) S in carbon disulfide ☐

(III) Fe in FeO_2^- ☐ (IV) Cl in potassium perchlorate ☐

b) Provide a brief explanation of the fact that even though the experimental evidence may support iron species (I), (III) seems more logical. (Hint: consider the naming of iron compounds and how they are distinguished.)

35. [4pts] Identify one of the possible elements by their periodic table symbol for (a) and (b), and write their respective ground-state electron configuration. (You can abbreviate the configuration. For example: [Ar]$4s^2 3d^5$)

	Symbol	*Configuration*
(a) a transition metal with eight paired 4d electrons		
(b) an alkaline earth with electrons in p orbitals		

36. [6pts] Fill in the correct responses below the following reaction. (NOTE: The reaction occurs in an acidic environment.)

$$Fe^{2+}(aq) + MnO_4^-(aq) \rightarrow Fe^{3+}(aq) + Mn^{2+}(aq)$$

The oxidation number of manganese in the reactant is _____ .

The reactant that is reduced is _____ .

The reducing agent is _____.

There are a total of _____ electrons transferred in the process.

When the equation is balanced, the products include _____ moles of water and _____ moles of H^+ (aq).

Show your work below.