CHEM 1314.02 and 1314.03
Exam III
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November 15, 2000

Name _____

TA's Name _____

Lab Section _____

INSTRUCTIONS:

1. This examination consists of a total of 9 different pages. The last three pages include a periodic table, some useful equations, a table of standard heats of formation and a solubility table. All work should be done in this booklet.

2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.

3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.

4. No credit will be awarded if your work is not shown in problems 3, 4a, 4b, 4c, and 5.

5. Point values are shown next to the problem number.

6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.

7. Look through the exam before beginning; plan your work; then begin.

8. Relax and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	_____ (26)	_____ (20)	_____ (27)	_____ (27)	_____ (100)

(12) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous

a) $Pb(NO_3)_{2(aq)} + Na_2S_{(aq)} \rightarrow \mathbf{PbS_{(s)}} + \mathbf{2NaNO_{3(aq)}}$

b) $C_5H_{12(aq)} + \mathbf{16}O_{2(g)} \rightarrow \mathbf{5CO_{2(g)}} + \mathbf{6H_2O_{(l)}}$

c) $\mathbf{2}NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow \mathbf{Na_2SO_{4(aq)}} + \mathbf{2H_2O_{(l)}}$

d) $Ba(OH)_2{\cdot}8H_2O_{(s)} + NH_4SCN_{(s)} \rightarrow \mathbf{Ba(SCN)_{2(aq)}} + \mathbf{10H_2O_{(l)}} + \mathbf{2NH_{3(g)}}$

(4) 2. Write the ionic and net ionic chemical equations for 1c).

1c)

Ionic equation:

$$\mathbf{2Na^+_{(aq)} + 2OH^-_{(aq)} + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow 2Na^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2H_2O_{(l)}}$$

Net Ionic equation:

$$\mathbf{\cancel{2Na^+_{(aq)}} + 2OH^-_{(aq)} + 2H^+_{(aq)} + \cancel{SO_4^{2-}{}_{(aq)}} \rightarrow \cancel{2Na^+_{(aq)}} + \cancel{SO_4^{2-}{}_{(aq)}} + 2H_2O_{(l)}}$$

$$\mathbf{2OH^-_{(aq)} + 2H^+_{(aq)} \rightarrow 2H_2O_{(l)}}$$

$$\mathbf{OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O_{(l)}}$$

calorimeter containing 75.0 g of water at 24.5 ˚C. The heat capacity of the calorimeter is 10.5 J ˚C^{-1}. Determine the final temperature of the system. Note: The specific heat of aluminum is 0.900 J g^{-1} ˚C^{-1}.

$$\mathbf{q_{Al,\,hot} = -(q_{water} + q_{calorimeter})}$$

$$\mathbf{mass_{Al} \cdot S.H._{Al} \cdot \Delta T_{Al,\,hot} = -(mass_{water} \cdot S.H._{water} \cdot \Delta T_{water} + HC_{calorimeter} \cdot \Delta T_{calorimeter})}$$

$$\mathbf{225\ g \cdot 0.900\ J\ g^{-1}\ ^\circ C^{-1} \cdot (T_f - 98.00\ ^\circ C) = -(75.0\ g \cdot 4.184\ J\ g^{-1}\ ^\circ C^{-1} \cdot (T_f - 24.5\ ^\circ C) + 10.5\ J\ ^\circ C^{-1} \cdot (T_f - 24.5\ ^\circ C))}$$

$$\mathbf{202.5\ J\ ^\circ C^{-1} \cdot (T_f - 98.00\ ^\circ C) = -(313.8\ J\ ^\circ C^{-1} \cdot (T_f - 24.5\ ^\circ C) + 10.5\ J\ ^\circ C^{-1} \cdot (T_f - 24.5\ ^\circ C))}$$

$$\mathbf{202.5\ J\ ^\circ C^{-1} \cdot (T_f - 98.00\ ^\circ C) = -(324.3\ J\ ^\circ C^{-1} \cdot (T_f - 24.5\ ^\circ C))}$$

$$\mathbf{202.5\ J\ ^\circ C^{-1}(T_f) - 19845\ J = -(324.3\ J\ ^\circ C^{-1} \cdot (T_f) - 7945\ J))}$$

$$\mathbf{526.8\ J\ ^\circ C^{-1}(T_f) = 27790\ J}$$

$$\mathbf{(T_f) = \frac{27790\ J}{526.8\ J\ ^\circ C^{-1}} = 52.8\ ^\circ C}$$

(20) 4. A hydrogen atom emits a photon of light with a wavelength of 1.875×10^{-6} m.

a) Calculate the frequency of this photon.

$$\upsilon = \frac{c}{\lambda}$$

$$\frac{2.9979 \times 10^{8} \text{ m s}^{-1}}{1.875 \times 10^{-6} \text{ m}} = 1.60 \times 10^{14} \text{ Hz (cps or s}^{-1}\text{)}$$

b) Calculate the energy of the photon.

$$E = h\upsilon$$

$$E = (6.626 \times 10^{-34} \text{ J s})\ 1.60 \times 10^{14} \text{ s}^{-1} = 1.06 \times 10^{-19} \text{ J}$$

c) Determine the initial energy level of the electron if the final energy level the electron has is $n = 3$.

$$\Delta E = -2.18 \times 10^{-18} \text{ J} \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

In the above equation ΔE is -1.06×10^{-19} J. We must add the negative sign because the photon is emitted by the atom as the electron falls from a higher energy level to a lower energy level.

$$-1.06 \times 10^{-19} \text{ J} = -2.18 \times 10^{-18} \text{ J} \left(\frac{1}{3_f^2} - \frac{1}{n_i^2} \right)$$

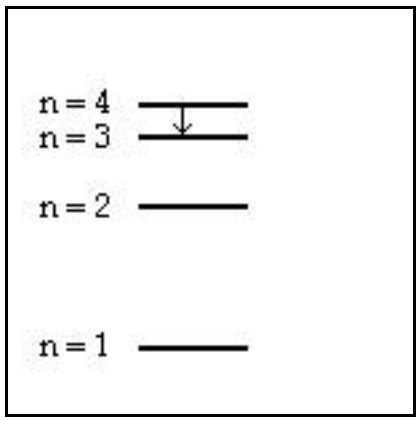
$$\frac{-1.06 \times 10^{-19} \text{ J}}{-2.18 \times 10^{-18} \text{ J}} = 0.0486 = \left(\frac{1}{3_f^2} - \frac{1}{n_i^2} \right)$$

$$0.0486 = \left(\frac{1}{9} - \frac{1}{n_i^2} \right)$$

$$\frac{1}{n_i^2} = \frac{1}{9} - 0.0486 = 0.0625$$

$$n^2 = 16.0 \text{ and } n = 4$$

d) Draw and label an energy level diagram for the hydrogen atom and show the transition for the electron as determined in c.



(10) 5. Calculate ΔH° for the following reaction,

$$SiO_{2(s)} + 4HF_{(g)} \rightarrow SiF_{4(g)} + 2H_2O_{(g)}$$

$\Delta H^\circ_{rxn} = \Sigma \Delta H^\circ_f$ **(products)** $- \Sigma \Delta H^\circ_f$ **(reactants)**

$\Delta H^\circ_{rxn} = \Delta H^\circ_f(SiF_4) + 2\Delta H^\circ_f(H_2O) - (\Delta H^\circ_f(SiO_2) + 2\Delta H^\circ_f(HF))$

$\Delta H^\circ_{rxn} = -910.9\ kJ + 2 \cdot -242\ kJ - (-1614.9\ kJ + 4 \cdot -273\ kJ)$

$\Delta H^\circ_{rxn} = -95.1\ kJ$

(12) 6. Write the electron configuration and indicate the number of unpaired electrons for each of the following in their ground state,

i. Cr **6** unpaired electrons

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ or $[Ar]4s^1 3d^5$

ii. I^- **0** unpaired electrons

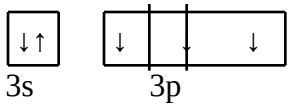
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$ or $[Kr]5s^2 4d^{10} 5p^6$

iii. Es **5** unpaired electrons

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 5p^6 7s^2 5f^{10} 6d^1$ or $[Rn]7s^2 5f^{10} 6d^1$

(5) 7. Draw the orbital diagram for the valence electrons for phosphorus in its ground state

The electron configuration for phosphorus is $1s^2 2s^2 2p^6 3s^2 3p^3$. There are five valence electron in phosphorus.



Multiple Choice: (27 points)

Print the letter (A, B, C, D) which corresponds to the answer selected.

8. **A**	9. **B**	10. **D**	11. **B**	12. **A**
13. **C**	14. **C**	15. **B**	16. **D**	

ONLY THE ANSWERS IN THE AREA ABOVE WILL BE GRADED. Select the most correct answer for each question. Each question is worth 3 points.

8. Which of these species has a standard enthalpy of formation equal to zero?

A) $F_{2(g)}$ B) $F_{(g)}$ C) $HF_{(aq)}$ D) $F^-_{(aq)}$

9. Which electron configuration is not allowed for either a neutral atom or an ion in its ground state?

A) $1s^2 2s^2 2p^3$
B) $1s^2 2s^1 2p^6$
C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

10. Which principal quantum number transition in a hydrogen atom will release the greatest amount of energy?

A) 1 → 3
B) 6 → 4
C) 3 → 5
D) 4 → 2

11. Which element in its ground state has the greatest number of unpaired electrons?

A) V (atomic number 23)
B) Fe (atomic number 26)
C) In (atomic number 49)
D) As (atomic number 33)

12. In a bomb calorimeter, reactions are carried out at

A) constant volume
B) constant pressure
C) constant temperature
D) 1 atm pressure and 0 ˚C

13. Which is a possible set of quantum numbers for a valence electron in phosphorus?

	n	l	m_l	m_s
A)	2	1	0	+1/2
B)	3	0	0	0
C)	3	1	-1	+1/2
D)	3	2	1	-1/2

14. Carbon reacts with oxygen according to this equation

$$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)}$$
$$\Delta H^\circ = -220 \text{ kJ}$$

I. The reaction is exothermic
II. ΔH°_f of CO is –220 kJ
III. The combustion of 0.5 mol of carbon produces 55 kJ of heat energy

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

15. Given the reactions

Reaction	ΔH (kJ mol^{-1})
$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$	–467
$MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)}$	–151

and the ΔH°_f for $H_2O_{(l)}$ is –286 kJ mol,$^{-1}$, the ΔH°_f for MgO is,

A) –904 kJ
B) –602 kJ
C) –316 kJ
D) –30.0 kJ

16. Which of the following processes/reactions is not exothermic?

A) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$
B) $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
C) $H_2O_{(g)} \rightarrow H_2O_{(l)}$
D) $SO_{2(s)} \rightarrow SO_{2(l)}$

Periodic Table of the Elements

	IA												IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008	IIA																2 **He** 4.00
2	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
3	11 **Na** 22.99	12 **Mg** 24.30	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	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** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	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** (98)	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
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	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)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 (261)	105 (262)	106 (263)												

Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Useful Information

$E_n = -2.18 \times 10^{-18}\ J \left(\frac{1}{n^2}\right)$ $r_n = 0.529 \times 10^{-8}\ n^2\ cm$ $h = 6.626 \times 10^{-34}\ J \cdot s$

$\Delta E = -2.18 \times 10^{-18}\ J \left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ $\lambda = \frac{c}{\nu}$ $E = h\nu$ $c = 3.00 \times 10^8\ \frac{m}{s}$

Specific heat of $H_2O_{(s)}$ $= 2.09\ \frac{J}{g \cdot °C}$ Specific heat of $H_2O_{(l)}$ $= 4.184\ \frac{J}{g \cdot °C}$

Specific heat of $H_2O_{(g)}$ $= 1.84\ \frac{J}{g \cdot °C}$ Heat of fusion of $H_2O_{(s)}$ $= 6.01\ \frac{kJ}{mol}$

Heat of vaporization of $H_2O_{(l)}$ $= 40.67\ \frac{kJ}{mol}$

$R = 0.08203\ \frac{L \cdot atm}{mol \cdot K}$ or $R = 8.314\ \frac{J}{mol \cdot K}$ $\Delta H = \Delta E + \Delta nRT$

q(heat flow) = mass · specific heat · ΔT

$q_{reaction} = -(q_{calorimeter} + q_{solution})$ $q_{reaction} = -(q_{calorimeter} + q_{water})$

$\Delta H^\circ_{rxn} = \Sigma\ n\Delta H^\circ_f\ (products) - \Sigma\ m\Delta H^\circ_f\ (reactants)$

Table of Standard Heats of Formation

Substance and State	ΔH_f° (kJ/mol)	Substance and State	ΔH_f° (kJ/mol)
C(*s*) (graphite)	0	$HNO_3(aq)$	-207.36
C(*s*) (diamond)	2	$HNO_3(l)$	-174.10
		HCl(*g*)	-92.3
$CH_4(g)$	–75	HBr(*g*)	-36.4
$CH_3OH(g)$	-201	HI(*g*)	26.5
$CH_3OH(l)$	-239	$I_{2(g)}$	62.25
$H_2CO(g)$	-116	$O_2(g)$	0
$CCl_4(l)$	-135.4	O(*g*)	249
HCOOH(*g*)	-363	$O_3(g)$	143
HCN(*g*)	135.1		
$CS_2(g)$	117.4	$N_2(g)$	0
$CS_2(l)$	89.7	$NH_3(g)$	-46
$C_2H_2(g)$	227	$NH_{3(aq)}$	-80
$C_2H_4(g)$	52	$NH_4^+(aq)$	-132
$CH_3CHO(g)$	-166	$N_2H_3CH_3(l)$	54
$C_2H_5OH(l)$	-278	$N_2H_{4(l)}$	50.6
$C_2H_5O_2N_{(g)}$	-533	NO(*g*)	90.25
$C_2H_6(g)$	-84.7	$NO_2(g)$	33.18
$C_3H_6(g)$	20.9	$N_2O(g)$	82.0
$C_3H_8(g)$	-104	$N_2O_4(g)$	9.16
$C_4H_{10}(g)$	-126	$N_2O_4(l)$	20
$CH_2 = CHCN(l)$	152		
$CH_3COOH(l)$	-484	$S_2Cl_{2(g)}$	-18
$C_6H_{12}O_6(s)$	-1275	$SO_{2(g)}$	-296.83
$TiO_2(s)$	-945	$H_2S_{(g)}$	-20.6
$Cl_2(g)$	0	$SOCl_{2(g)}$	-213
$Cl_2(aq)$	-23		
$Cl^-(aq)$	-167	$SiCl_{4(g)}$	-657
		$SiO_{2(s)}$	-910.94
		$SiF_{4(g)}$	-1614.9
		HF(*g*)	-273
H*(g)*	217	$TiO_2(s)$	-944.7
$H^+(aq)$	0	$TiCl_{4(g)}$	-763
$OH^{-}{}_{(aq)}$	-230		
$H_2O_{(l)}$	-286	ZnO(*s*)	-348
$H_2O_{(g)}$	-242	ZnS(*s*)	-206

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	soluble	except Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble