Chem 1141
Fall 2012
Exam 3A

Name: KEY

Please write your full name, and which exam version (3A) you have on the scantron sheet.

Multiple Choice. [3 points each.] Record your answers to the multiple choice questions on the scantron sheet.

Q1. Which element exists as a diatomic gas in its most stable form at 1 atm and 25 °C? $H_2(g)$ $N_2(g)$ $O_2(g)$ $F_2(g)$ $Cl_2(g)$

a) helium b) carbon c) sulfur d) nitrogen e) argon

Q2. The pressure of a gas at STP is: STP: 1atm, 0°C

a) 1 atm b) 1 Pa c) 1 mmHg d) 1 torr e) 1 N

Q3. The law that states that the pressure of a gas is inversely proportional to volume is:

a) Avogadro's b) Boyle's c) Charles' d) Gay Lussac's e) Newton's

Avogadro: $V \propto n$
Boyle: $P \propto V^{-1}$
Charles: $V \propto T$
Gay-Lussac: $P \propto T$

Q4. In the van der Waals equation for a gas, what does the constant b account for?

a) The tendency of the molecules to stick together
b) The molecules can be cooled down to form a liquid
c) The temperature conversion from degrees celcius to Kelvin
d) The molecules are not all diatomic
e) The molecules have size

Q5. Given the following thermochemical equation:

$H_2O(s) \rightarrow H_2O(l) \quad \Delta H° = +6.01$ kJ/mol

calculate the value of $\Delta H°$ for the following reaction:

$2H_2O(l) \rightarrow 2H_2O(s) \quad \Delta H° = ???$

reverse and double: $\Delta H \times -2$ (reverse, double)

a) –6.01 kJ/mol b) –12.02 kJ/mol c) +6.01 kJ/mol
d) +12.02 kJ/mol e) 36.1 kJ/mol

Q6. A reaction with a negative value of ΔH is said to be:

a) Exogonic b) Endergonic c) Exothermic d) Endothermic

Q7. Given the thermochemical equation:

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l) \quad \Delta H° = -2598.8$ kJ/mol

Then how much heat will be released when 3 mol of C_2H_2 is burned?

a) 2598.8 kJ b) 866 kJ c) 7796.4 kJ d) 1732.5 kJ e) 3898.2 kJ

$3 \text{ mol } C_2H_2 \times \frac{-2598.8 \text{ kJ}}{2 \text{ mol } C_2H_2} = -3898.2 \text{ kJ}$ (released) need to make 1 mol of substance from elements in their most stable form!

Q8. The reaction corresponding to the standard enthalpy of formation of trinitrotoluene, $C_6H_3N_3O_3(s)$ is:

a) $C_6H_3N_3O_3(s) \rightarrow 6C(s) + 3H(g) + 3N(g) + 3O(g)$

b) $6C(s, graphite) + H_3(g) + N_3(g) + O_3(g) \rightarrow C_6H_3N_3O_3(s)$

c) $6C(s, graphite) + \frac{3}{2} H_2(g) + \frac{3}{2} N_2(g) + O_3(g) \rightarrow C_6H_3N_3O_3(s)$

d) $6C(s, graphite) + \frac{3}{2} H_2(g) + \frac{3}{2} N_2(g) + \frac{3}{2} O_2(g) \rightarrow C_6H_3N_3O_3(s)$

e) $12C(s, graphite) + 3 H_2(g) + 3 N_2(g) + 3 O_2(g) \rightarrow 2 C_6H_3N_3O_3(s)$

Q9. The term given to a particle of light is a(n):

a) Wave b) Particle c) proton d) electron e) photon

Q10. The expression used to calculate the probability of an electron in space: $\psi^2 \propto$ prob (Born Interpretation)

a) ψ b) ψ^2 c) ψ^3 d) ψ^4 e) $1/\psi$

Q11. The name given to the quantum number, l

a) principal quantum number b) electron-spin quantum number

c) angular momentum quantum number d) magnetic quantum number

Q12. The electron configuration for an atom of Cr is: ½-full d-subshell!

a) [He] $2s^22p^2$ b) [Ne] $3d^4$ c) [Ar] $4s^23d^4$ d) [Ar] $4s^13d^5$ e) [Ar] $3d^7$

Q13. The principle that says that the electrons in an atom prefer to enter orbitals in the same subshell with parallel spins, before pairing up:

a) Hund's rule b) Paramagnetic rule c) Pauli's exclusion rule

d) Bohr's condition e) Schrödinger's equation

Q14. What is the oxidation number of N is the compound: KNO_2? (+1, −2)

a) +5 b) +3 c) −1 d) −3 e) −5

Q15. Which SI prefix means $x10^{-9}$?

a) μ b) m c) k d) n e) f

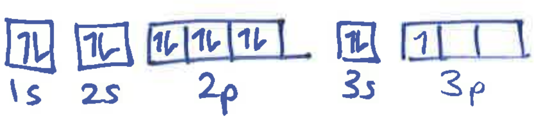
Short Response.

Show all work to receive credit. You must use the factor-label (conversion-factor) method for all conversions. Be sure to show all units and write your answers using the correct number of significant figures or decimal places.

Q16. [8 pts.] Write the full electron configuration and orbital diagrams for the following atoms:

a) Al

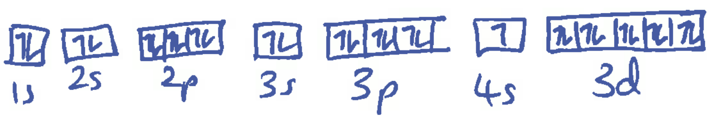
$1s^22s^22p^63s^23p^1$



b) Cu

$1s^22s^22p^63s^23p^64s^13d^{10}$

(Auf-bau exception! full d-subshell)



Q17. [8 pts.] Given the following data:

ΔH_f° / kJ·mol^{-1}	+226.6	0	–393.5	–241.8
Compound	$C_2H_2(g)$	$O_2(g)$	$CO_2(g)$	$H_2O(g)$

(i) Predict ΔH° for the following reaction:

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$$

$$\Delta H^\circ = \sum n \cdot \Delta H_f^\circ (\text{products}) \ominus \sum m \cdot \Delta H_f^\circ (\text{reactants})$$

$$= [4 \times \Delta H_f^\circ (CO_2) + 2 \times \Delta H_f^\circ (H_2O)] - [2 \times \Delta H_f^\circ (C_2H_2) + 5 \times \Delta H_f^\circ (O_2)]$$

$$= [4 \times -393.5 \tfrac{kJ}{mol} + 2 \times -241.8 \tfrac{kJ}{mol}] - [2 \times 226.6 \tfrac{kJ}{mol} + 5 \times 0]$$

$$= -2510.8 \text{ kJ/mol}$$

(ii) Calculate how much heat is absorbed/released (state which!) if 12.0 g of $C_2H_2(g)$ and 15.0 g of $O_2(g)$ react.

XS

$$12.0g\ C_2H_2 \times \frac{1 mol\ C_2H_2}{26.04g\ C_2H_2} \times \frac{-2510.8 kJ}{2 mol\ C_2H_2} = -579 kJ$$

$$15.0g\ O_2 \times \frac{1 mol\ O_2}{32.00g\ O_2} \times \frac{-2510.8 kJ}{5 mol\ O_2} = (-235 kJ)$$

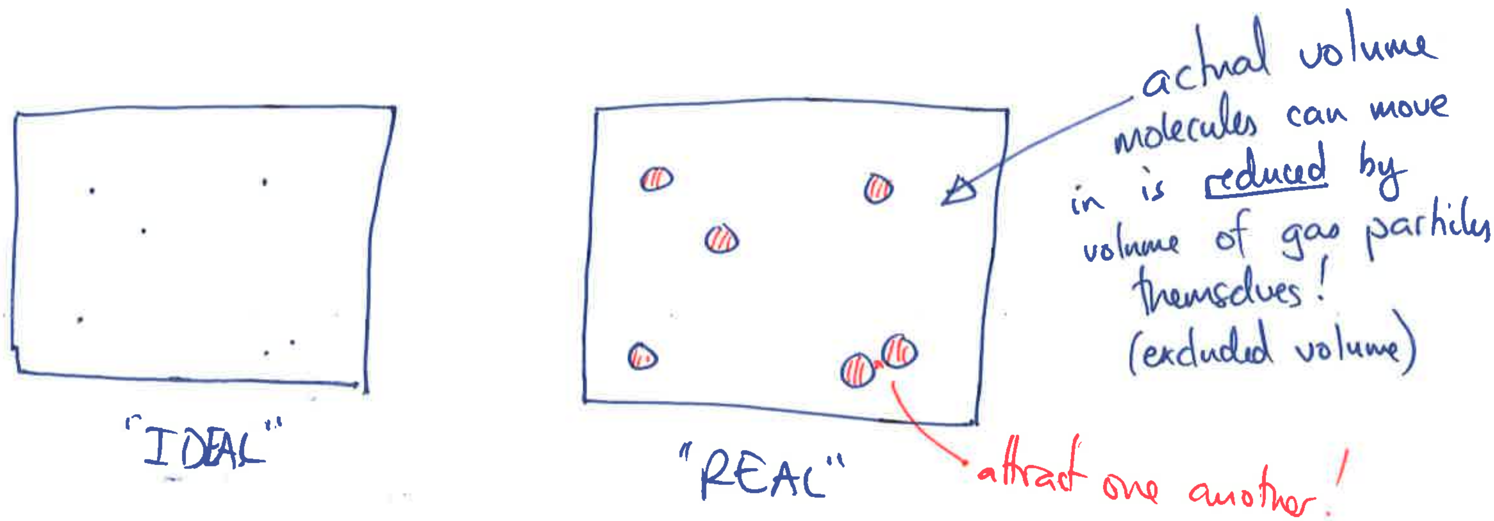
LR

$\Rightarrow$ 235 kJ of heat is released.

Q18. [8 pts.] Give a detailed explanation of how *real* gases differ from *ideal* gases.

The particles in real gases attract one-another + occupy volume!

" ——————— " ideal gas particles do not attract/repel one another, and the particles have no volume of their own!



240.K

Q19. [8 pts.] 5.0 g of Ar(g) and 5.0 g of Ne(g) is released into an empty 5.0-L container at a temperature of 17 °C. Calculate the partial pressures of each gas, the mole-fractions of each gas, and the total pressure inside the container.

Ar: $\frac{5.0\,g\,Ar \mid 1\,mol\,Ar}{\mid 39.95\,g\,Ar} = 0.125\,mol\,Ar$, $P_{Ar} = \frac{n_{Ar}RT}{V} = \frac{0.125\,mol \times 0.08206\,\frac{atm \cdot L}{mol \cdot K} \times 290.K}{5.0\,L} = 0.596\,atm$

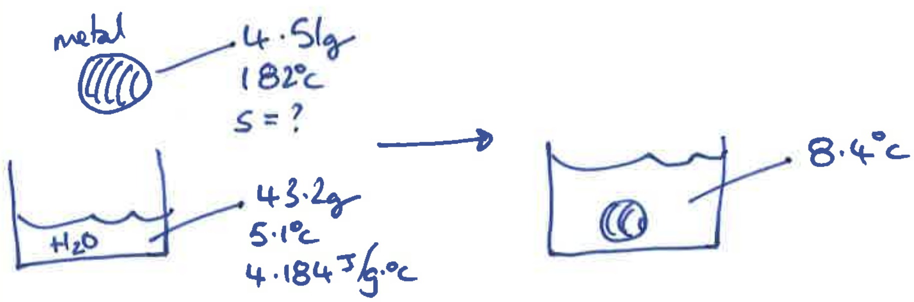
Ne: $\frac{5.0\,g\,Ne \mid 1\,mol\,Ne}{\mid 20.18\,g\,Ne} = 0.248\,mol\,Ne$, $P_{Ne} = \frac{n_{Ne}RT}{V} = 1.18\,atm$

$P_{TOT} = P_{Ar} + P_{Ne} = 0.596\,atm + 1.18\,atm = 1.776\,atm = 1.8\,atm$

$\chi_{Ar} = \frac{n_{Ar}}{n_{TOT}} = \frac{0.125\,mol}{0.125\,mol + 0.248\,mol} = 0.335$, $\chi_{Ne} = \frac{n_{Ne}}{n_{TOT}} = 0.665$

note: $\sum_i \chi_i = 1$ (sum of mole fractions = 1)

Q20. [8 pts.] A 4.51 g sample of a metal at 182 °C is dropped into a calorimeter containing 43.2 g of water at 5.1 °C. Given that the water has a specific heat of 4.184 J/g·°C, and assuming that the calorimeter forms a perfectly isolated system, calculate the specific heat of the metal if the final temperature of the system is 8.4 °C.



1st Law: $q_{H_2O} + q_{metal} = 0$

$\Rightarrow m_{H_2O} \cdot s_{H_2O} \cdot \Delta t_{H_2O} + m_{metal} \cdot s_{metal} \cdot \Delta t_{metal} = 0$

$\Rightarrow s_{metal} = -\frac{m_{H_2O} \cdot s_{H_2O} \cdot \Delta t_{H_2O}}{m_{metal} \cdot \Delta t_{metal}}$

$= -\frac{(43.2\,g)(4.184\,J/g \cdot °C)(8.4°C - 5.1°C)}{(4.51\,g)(8.4°C - 182°C)}$

$= 0.76\,J/g \cdot °C$

Q21. [5 pts.] Calculate the empirical formula of a substance containing 40.1 percent carbon, 6.6 percent hydrogen, and 53.3 percent oxygen by mass.

Assume 100g sample, then

$$\frac{40.1\,g\,C \mid 1\,mol\,C}{\mid 12.01\,g\,C} = 3.34\,mol\,C$$

$$\frac{6.6\,g\,H \mid 1\,mol\,H}{\mid 1.01\,g\,H} = 6.5\,mol\,H$$

$$\frac{53.3\,g\,O \mid 1\,mol\,O}{\mid 16.00\,g\,O} = 3.33\,mol\,O$$

$\Rightarrow$ 3.34 mol C : 6.5 mol H : 3.33 mol O

$\div$ 3.33 mol

$\Rightarrow$ 1.00 C : 2.0 H : 1.00 O

$\Rightarrow$ $\boxed{CH_2O}$

Q22. [10 pts.] Write the molecular, full-ionic, and net-ionic equation for the reaction between aqueous sodium carbonate and aqueous magnesium nitrate.

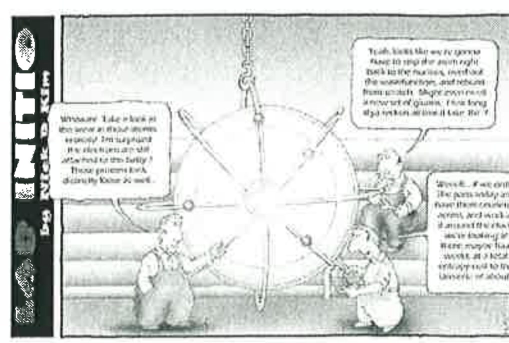
Molecular: $Na_2CO_3(aq) + Mg(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + MgCO_3(s)\downarrow$

Full-Ionic:

$2Na^+(aq) + CO_3^{2-}(aq) + Mg^{2+}(aq) + 2NO_3^-(aq) \rightarrow 2Na^+(aq) + 2NO_3^-(aq) + MgCO_3(s)\downarrow$

Net-Ionic:

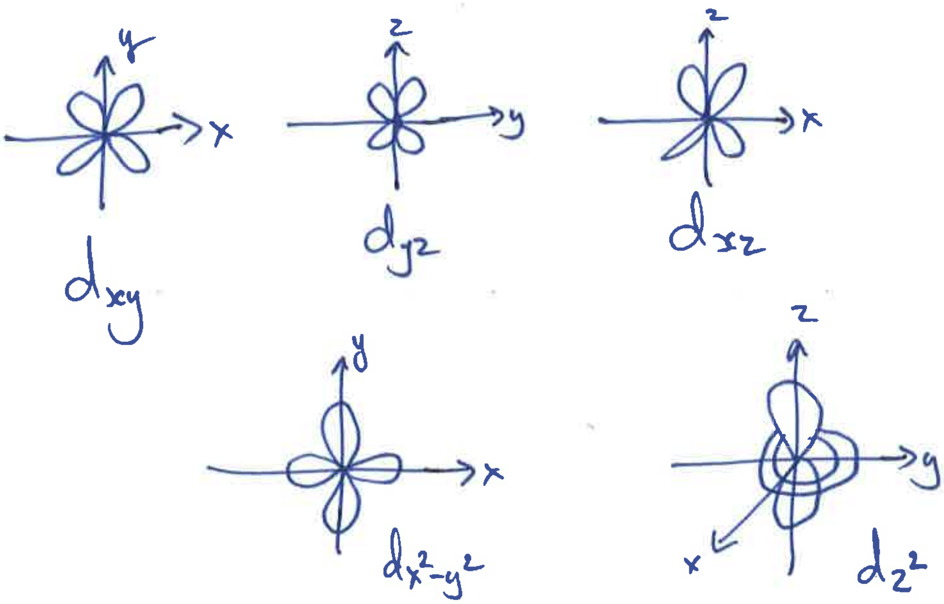
$Mg^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MgCO_3(s)\downarrow$



Quantum Mechanics

BONUS Question

Sketch and label the five different 3d orbitals.



Partial List of Solubility Rules

TABLE 4.2 Solubility Rules for Common Ionic Compounds in Water at 25°C

Soluble Compounds	Exceptions
Halides (Cl^-, Br^-, I^-)	Halides of Ag^+, Hg_2^{2+}, and Pb^{2+}
Sulfates (SO_4^{2-})	Sulfates of Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}

Insoluble Compounds	Exceptions
Carbonates (CO_3^{2-}), phosphates (PO_4^{3-}), chromates (CrO_4^{2-}), and sulfides (S^{2-})	Compounds containing alkali metal ions and the ammonium ion
Hydroxides (OH^-)	Compounds containing alkali metal ions and the Ba^{2+} ion

Useful Information:

$pV = nRT$ $\quad \left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$ $\quad$ 1 atm = 760 mmHg = 101325 Pa $\quad R = 0.08206 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}$

$M_1V_1 = M_2V_2$ $\quad N_A = 6.022 \times 10^{23}$ $\quad q = m \cdot s \cdot \Delta t$ $\quad q = C \cdot \Delta t$

$c = \nu\lambda$ $\quad E = h\nu$ $\quad c = 3.00 \times 10^8$ m/s $\quad h = 6.626 \times 10^{-34}$ J·s

$E_n = -R_H\left(\frac{1}{n^2}\right)$ $\quad R_H = 2.18 \times 10^{-18}$ J $\quad \lambda = \frac{h}{mu}$

Periodic Table

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.01																	2 **He** 4.00
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
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** 39.1	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** 65.39	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** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.9	56 **Ba** 137.3	57 **La*** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	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	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac^** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)							

*	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** 157.3	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
^	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	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)