Chem 1141
Fall 2011
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 of the following elements are gases at room temperature and pressure?
a) sulfur b) chlorine c) bromine d) beryllium e) manganese

Q2. If the atmospheric pressure is 755 mmHg, then what is the pressure of the gas contained in the following mercury-filled manometer? (Note: This manometer is OPEN to the atmosphere!)

a) 65 mmHg b) 690 mmHg c) 755 mmHg d) 760 mmHg e) 820 mmHg

Q3. 200. mL of a gas at a pressure of 60.0 mmHg is compressed to a volume of 50.0 mL. What will its new pressure be?
a) 15.0 mmHg b) 120. mmHg c) 180. mmHg d) 240. mmHg e) 260. mmHg

Q4. Which gas law states that the volume of a gas is directly proportional to its temperature?
a) Avogadro's b) Boyle's c) Charles d) Gay-Lussac's e) Dulong's

Q5. What must be increased to increase the average kinetic energy of gas molecules?
a) Pressure b) Volume c) Moles d) Gas Constant e) Temperature

Q6. Which type of thermodynamic system is consistent with the fact that heat may flow between the system and the surroundings, but matter cannot?
a) Open b) Closed c) Isolated d) Universe e) First

Q7. Given the following thermochemical equation:
$2Fe(s) + \frac{3}{2} O_2(g) \rightarrow Fe_2O_3(s) \quad \Delta H° = -826.0$ kJ/mol
How much heat will be released if four moles of iron reacts with an excess of oxygen?
a) 206.5 kJ b) 413.0 kJ c) 826.0 kJ d) 1652 kJ e) 3304 kJ

Q8. Given the following thermochemical equation:
$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g) \quad \Delta H° = -241.8$ kJ/mol
What will $\Delta H°$ be for the thermochemical equation:
$2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$
a) –241.8 kJ/mol b) +241.8 kJ/mol c) –120.9 kJ/mol d) +120.9 kJ/mol
e) +483.6 kJ/mol

Q9. Which thermochemical equation corresponds to $\Delta H_f°(N_2O(g))$?
a) $2N(g) + O(g) \rightarrow N_2O(g)$
b) $N_2O(g) \rightarrow 2N(g) + O(g)$
c) $N_2(g) + O(g) \rightarrow N_2O(g)$
d) $2N_2(g) + O_2(g) \rightarrow 2N_2O(g)$
e) $N_2(g) + \frac{1}{2} O_2(g) \rightarrow N_2O(g)$

Q10. What is the frequency of UV light with a wavelength of 254 nm?
a) 1.18×10^{15} Hz b) 1.18×10^{6} Hz c) 8.47×10^{-7} Hz d) 8.47×10^{-16} Hz
e) 76.2 Hz

Q11. Which type of EM radiation has the largest energy per photon?
a) Radiowaves b) Red-Light c) Green-Light d) Microwaves
e) Infrared

Q12. Which electron transition in the hydrogen atom would lead to *emission* of the longest wavelength of light?
a) 2 → 1 b) 3 → 1 c) 4 → 1 d) 5 → 1 e) 6 → 5

Q13. What letter is used for an electron with an angular momentum quantum number (ℓ) of 2?
a) d b) s c) p d) m_l e) n

Q14. Which principle says that electrons are added in lower energy subshells, before entering higher-energy subshells?
a) Pauli b) Heisenberg c) Aufbau d) Hund e) de Broglie

Q15. Which of the following atoms will be paramagnetic?
a) hydrogen b) helium c) magnesium d) neon e) beryllium

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. [4 pts.] Write out the FULL electron configuration of the following atoms:

a) Li $1s^2 2s^1$

b) Ti $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

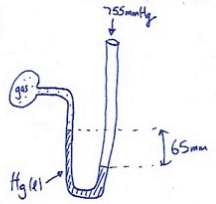
c) Cu $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ (aufbau exception... borrows $1e^-$ from 4s subshell to obtain 100% full 3d subshell)

d) Br $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

Exam 3A Multiple Choice

Q1. B Some other gaseous elements include:
H_2, O_2, N_2, F_2, Cl_2, He, Ne, Ar, Kr, Xe, Rn
Notice: $Br_2(\ell)$ (one of only two liquid elements!)

Q2. B



Clearly, $P_{gas} < 755\,mmHg$ because gas is "sucking" mercury up to a higher level! (Air is pushing Hg ...)

- If mercury levels were equal, $P_{gas} = 755\,mmHg$
- Since mercury levels are not equal,

$P_{gas} = 755\,mmHg \ominus 65\,mmHg = 690.\,mmHg$

gas is lower in pressure than air by this amount.

Q3. D. Long Method: $P_1\checkmark V_1\checkmark = \overset{?}{P_2}\checkmark V_2\checkmark \Rightarrow P_2 = \frac{P_1V_1}{V_2} = \frac{60.0\,mmHg \times 200.\,mL}{50.0\,mL}$

$= 240.\,mmHg$

Easy method: ($P \propto 1/V$ Boyle) Vol = 4× smaller ⇒ Pres = 4× larger

$= 4 \times 60 = 240\,mmHg$

Q4. C Charles: $V \propto T$ Avogadro: $V \propto n$
Boyle: $P \propto 1/V$ Know your gas ABC's!

Q5. E For gases, $\overline{KE} \propto T(K)$

Q6. B Open: matter ⟷, energy ⟷ , Closed: matter ⟷✗, energy ⟷

Isolated: matter ⟷✗, energy ⟷✗

Q7. D. $2Fe(s) + \frac{3}{2}O_2(g) \longrightarrow Fe_2O_3(s)$; $\Delta H^\circ = -826.0\,\frac{kJ}{mol}$

ΔH° is a conversion factor! $\frac{-826.0\,kJ}{2\,mol\,Fe}$, $\frac{-826.0\,kJ}{\frac{3}{2}\,mol\,O_2}$, $\frac{-826.0\,kJ}{1\,mol\,Fe_2O_3}$

$\frac{4\,mol\,Fe}{2\,mol\,Fe} \left| \frac{-826.0\,kJ}{} \right. = -1652\,kJ$ ↳ released!

Q8. E $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$; $\Delta H^\circ = -241.8\,\frac{kJ}{mol}$

reverse + double ↳ $2H_2O(g) \longrightarrow 2H_2(g) + O_2(g)$; $\Delta H^\circ = +483.6\,kJ/mol$ (reverse sign + double)

Q9. E. Remember: ΔH_f° refers to formation of 1 mole of substance from its elements in their most stable form.
Hydrogen: $H_2(g)$, Oxygen: $O_2(g)$

Q10. A. $c = \nu\lambda \Rightarrow \nu = c/\lambda = \frac{3.00\times10^{8}\,m/s}{254\times10^{-9}\,m}$

$n = \times10^{-9}$

$= 1.18\times10^{15}\,1/s$ ↳ or s^{-1} or Hz

Q11. C $E = \frac{hc}{\lambda} \Rightarrow E\uparrow\ \lambda\downarrow$

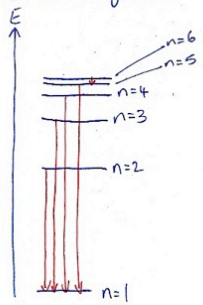
increasing → λ

γ-rays X-rays UV V I B G Y O R infrared microwaves radiowaves
C B E D A

smallest λ
largest E

Q12. E

H-Atom Energy Levels



$E_n = \frac{R_H}{n^2}$

6→5 transition = smallest loss of E

since $E_{photon} = \frac{hc}{\lambda} \propto 1/\lambda$

small E = large λ ⇒ (E)

Q13. A

ℓ	0	1	2	3
code	s	p	d	f

Q14. C

Aufbau (German = Building-Up)

Q15. A

H: $1s^1$ ↑ (1s) unpaired e^- = paramagnetic

He: $1s^2$ ↑↓ (1s) all es are paired = diamagnetic

...

must be paramagnetic

Easy method: Impossible to pair odd # es

⇒ $_1H$ $1e^-$

$_2He$ $_{12}Mg$ $_{10}Ne$ $_4Be$

could be paramagnetic/diamagnetic... need orbital diagram!

Q17. [6 pts.] 25.0 mL of an ideal gas at a temperature of 285 K and a pressure of 451 mmHg is allowed to warm up to a temperature of 371 K, while its pressure drops to 232 mmHg. What will its final volume be?

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2} = \frac{451\,mmHg \times 25.0\,mL \times 371\,K}{285\,K \times 232\,mmHg} = 63.3\,mL$ (3 s.f.)

(combined gas law)

Q18. [10 pts.] Write formulas for the following compounds:

a) magnesium phosphate $Mg_3(PO_4)_2$

b) trichlorine pentanitride Cl_3N_5

c) copper(I) sulfite Cu_2SO_3

d) sulfuric acid H_2SO_4

Q19. [10 pts.] Determine the empirical formula of a compound that is 29.0 % sodium, 40.5 % sulfur, and 30.4 % oxygen by weight.

Assume 100 g sample

$29.0\,g\,Na \times \frac{1\,mol\,Na}{22.99\,g\,Na} = 1.26\,mol\,Na$

$40.5\,g\,S \times \frac{1\,mol\,S}{32.07\,g\,S} = 1.26\,mol\,S$

$30.4\,g\,O \times \frac{1\,mol\,O}{16.00\,g\,O} = 1.90\,mol\,O$

$\Rightarrow \frac{1.26\,mol\,Na}{1.26\,mol} : \frac{1.26\,mol\,S}{1.26\,mol} : \frac{1.90\,mol\,O}{1.26\,mol}$

⇒ 1.00 Na : 1.00 S : 1.51 O

double: 2.00 Na : 2.00 S : 3.02 O

≈ 2 Na : 2 S : 3 O

⇒ $Na_2S_2O_3$

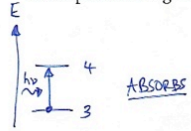
Q20. [8 pts.] 20.0 mL of 3.00 M HCl(aq) is added to an excess of Na_2CO_3(aq). What volume of gas is formed at a temperature of 301 K and a pressure of 1.03 atm? *Hint: Start by writing a balanced chemical equation!*

$2HCl(aq) + Na_2CO_3(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

$$20.0\,mL \left|\frac{1\,L}{1000\,mL}\right| \frac{3.00\,mol\,HCl}{1\,L} \left|\frac{1\,mol\,CO_2}{2\,mol\,HCl}\right| = 0.0300\,mol\,CO_2(g)$$

$$pV = nRT \Rightarrow V = \frac{nRT}{p} = \frac{0.0300\,mol \times 0.08206\,\frac{atm\cdot L}{mol\cdot K} \times 301\,K}{1.03\,atm} = 0.719\,L$$

Q21. [10 pts.] An electron in a hydrogen atom undergoes a transition from $n = 3$ to $n = 4$. Calculate the wavelength of the photon of light emitted/absorbed (state which).



ABSORBS

$$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) = 2.18\times10^{-18}\,J\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = +1.06\times10^{-19}\,J$$

$$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.626\times10^{-34}\,J\cdot s \times 3.00_{FR}\times10^{8}\,m\cdot s^{-1}}{1.06\times10^{-19}\,J}$$

$$= 1.88\times10^{-6}\,m$$

Q22. [7 pts.] Given the following thermochemical equations:

(1) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$; $\Delta H° = -91.8$ kJ/mol
(2) $C(s, graphite) + 2H_2(g) \rightarrow CH_4(g)$; $\Delta H° = -74.9$ kJ/mol
(3) $H_2(g) + 2C(s, graphite) + N_2(g) \rightarrow 2HCN(g)$; $\Delta H° = +270.3$ kJ/mol

Using Hess's Law, determine $\Delta H°$ for the following equation:

$HCN(g) + 3H_2(g) \longrightarrow CH_4(g) + NH_3(g)$

Halve (1) $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \longrightarrow NH_3(g)$ $\Delta H° = \frac{1}{2} \times -91.8 = -45.9$ kJ/mol

do not change (2) $C(s,graphite) + 2H_2(g) \longrightarrow CH_4(g)$ $\Delta H° = -74.9$ kJ/mol

reverse + halve (3) $HCN(g) \longrightarrow \frac{1}{2}H_2(g) + C(s,graphite) + \frac{1}{2}N_2(g)$; $\Delta H° = -\frac{1}{2} \times 270.3 = -135.15$ kJ/mol

$HCN(g) + 3H_2(g) \longrightarrow CH_4(g) + NH_3(g)$; $\Delta H° = -256.0$ kJ/mol (1 d.p.)

BONUS Questions:

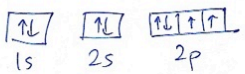
a) What is the de Broglie wavelength of a 2.0 kg ball travelling at a speed of 135 m/s?

$$\lambda = \frac{h}{m\cdot u} = \frac{6.626\times10^{-34}\,J\cdot s}{2.0\,kg \times 135\,m/s} = 2.45\times10^{-36}\,m$$

(since $1\,J = 1\,kg\,m^2/s^2$)

b) Write out the orbital diagram for an oxygen atom.

O: $1s^2 2s^2 2p^4$



Chem 1141
Fall 2011
Exam 3B

Name: KEY

Please write your full name, and which exam version (3B) 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 type of thermodynamic system is consistent with the fact that heat may flow between the system and the surroundings, but matter cannot?

a) Open (b) Closed c) Isolated d) Universe e) First

Q2. Given the following thermochemical equation:

$2Fe(s) + \frac{3}{2} O_2(g) \rightarrow Fe_2O_3(s) \quad \Delta H° = -826.0$ kJ/mol

How much heat will be released if four moles of iron reacts with an excess of oxygen?

a) 206.5 kJ b) 413.0 kJ c) 826.0 kJ (d) 1652 kJ e) 3304 kJ

Q3. Given the following thermochemical equation:

$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g) \quad \Delta H° = -241.8$ kJ/mol

What will $\Delta H°$ be for the thermochemical equation:

$2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$

a) –241.8 kJ/mol b) +241.8 kJ/mol c) –120.9 kJ/mol d) +120.9 kJ/mol
(e) +483.6 kJ/mol

Q4. Which thermochemical equation corresponds to $\Delta H_f°(N_2O(g))$?

a) $2N(g) + O(g) \rightarrow N_2O(g)$ b) $N_2O(g) \rightarrow 2N(g) + O(g)$
c) $N_2(g) + O(g) \rightarrow N_2O(g)$ d) $2N_2(g) + O_2(g) \rightarrow 2N_2O(g)$
(e) $N_2(g) + \frac{1}{2} O_2(g) \rightarrow N_2O(g)$

Q5. What ~~is the frequency~~ of UV light with a wavelength of 254 nm?

(a) 1.18×10^{15} Hz b) 1.18×10^{6} Hz c) 8.47×10^{-7} Hz d) 8.47×10^{-16} Hz
e) 76.2 Hz

Q6. Which type of EM radiation has the largest energy per photon?

a) Radiowaves b) Red-Light (c) Green-Light d) Microwaves
e) Infrared

Q7. Which electron transition in the hydrogen atom would lead to *emission* of the longest wavelength of light?

a) $2 \rightarrow 1$ b) $3 \rightarrow 1$ c) $4 \rightarrow 1$ d) $5 \rightarrow 1$ (e) $6 \rightarrow 5$

Q8. What letter is used for an electron with an angular momentum quantum number (ℓ) of 2?

(a) d b) s c) p d) m_l e) n

Exam 3B Multiple Choice.

Exam 3B	Exam 3A
Q1	Q6
2	7
3	8
4	9
5	10
6	11
7	12
8	13
9	14
10	15
11	1
12	2
13	3
14	4
15	5

* Final Volume is 100. mL ⇒ Final Pressure is 120 mm Hg ($\frac{1}{2}V$, 2×P ~ BOYLE!)

Q9. Which principle says that electrons are added in lower energy subshells, before entering higher-energy subshells?

a) Pauli b) Heisenberg **c) Aufbau** d) Hund e) de Broglie

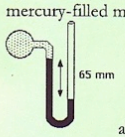
Q10. Which of the following atoms will be paramagnetic?

a) hydrogen b) helium c) magnesium d) neon e) beryllium

Q11. Which of the following elements are gases at room temperature and pressure?

a) sulfur **b) chlorine** c) bromine d) beryllium e) manganese

Q12. If the atmospheric pressure is 755 mmHg, then what is the pressure of the gas contained in the following mercury-filled manometer? (Note: This manometer is OPEN to the atmosphere!)



a) 65 mmHg **b) 690 mmHg** c) 755 mmHg d) 760 mmHg e) 820 mmHg

Q13. 200. mL of a gas at a pressure of 60.0 mmHg is compressed to a volume of 100. mL. What will its new pressure be?

a) 15.0 mmHg **b) 120. mmHg** c) 180. mmHg d) 240. mmHg e) 260. mmHg

Q14. Which gas law states that the volume of a gas is directly proportional to its temperature?

a) Avogadro's b) Boyle's **c) Charles** d) Gay-Lussac's e) Dulong's

Q15. What must be increased to increase the average kinetic energy of gas molecules?

a) Pressure b) Volume c) Moles d) Gas Constant **e) Temperature**

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. [4 pts.] Write out the FULL electron configuration of the following atoms:

a) B $1s^2 2s^2 2p^1$

b) Cr $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ (aufbau exception)

c) Ga $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$

d) Y $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$

Q17. [6 pts.] 35.0 mL of an ideal gas at a temperature of 285 K and a pressure of 451 mmHg is allowed to warm up to a temperature of 371 K, while its volume is compressed to 25.0 mL. What will its final pressure be?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow P_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{V_2} = \frac{451\,\text{mmHg} \times 35.0\,\text{mL} \times 371\,\text{K}}{285\,\text{K} \times 25.0\,\text{mL}} = 822\,\text{mmHg}$$

Q18. [10 pts.] Write formulas for the following compounds:

a) ammonium sulfate $(NH_4)_2SO_4$

b) tetrachlorine decanitride Cl_4N_{10}

c) iron(II) nitrate $Fe(NO_3)_2$

d) hydrobromic acid $HBr(aq)$

Q19. [10 pts.] Determine the empirical formula of a compound that is 24.2 % sodium, 33.7 % sulfur, and 42.1 % oxygen by weight.

Assume 100g sample

$$24.2\,\text{g Na} \left| \frac{1\,\text{mol Na}}{22.99\,\text{g Na}} \right. = 1.05\,\text{mol Na}$$

$$33.7\,\text{g S} \left| \frac{1\,\text{mol S}}{32.07\,\text{g S}} \right. = 1.05\,\text{mol S}$$

$$42.1\,\text{g O} \left| \frac{1\,\text{mol O}}{16.00\,\text{g O}} \right. = 2.63\,\text{mol O}$$

ratio

$$\frac{1.05\,\text{mol Na} : 1.05\,\text{mol S} : 2.63\,\text{mol O}}{1.05\,\text{mol}}$$

$1.00\,\text{Na} : 1.00\,\text{S} : 2.50\,\text{O}$

double

$2\,\text{Na} : 2\,\text{S} : 5\,\text{O}$

$\Rightarrow \boxed{Na_2S_2O_5}$

hydrobromic acid! (See Q18d)

Q20. [8 pts.] 42.0 mL of 3.00 M HBr(aq) is added to an excess of K_2CO_3(aq). What volume of gas is formed at a temperature of 321 K and a pressure of 1.09 atm? *Hint: Start by writing a balanced chemical equation!*

$2HBr(aq) + K_2CO_3(aq) \longrightarrow 2KBr(aq) + H_2O(l) + CO_2(g)$

$$\frac{42.0\,mL}{1}\left|\frac{1\,L}{1000\,mL}\right|\frac{3.00\,mol\,HBr}{1\,L}\left|\frac{1\,mol\,CO_2}{2\,mol\,HBr}\right. = 0.0630\,mol\,(CO_2(g))$$

$$PV=nRT \Rightarrow V=\frac{nRT}{P}=\frac{0.0630\,mol \times 0.08206\,\frac{atm\cdot L}{mol\cdot K} \times 321\,K}{1.09\,atm} = 1.52\,L$$

Q21. [7 pts.] Given the following thermochemical equations:

$C(s, graphite) + 2H_2(g) \rightarrow CH_4(g)$; $\Delta H° = -74.9$ kJ/mol

$H_2(g) + 2C(s, graphite) + N_2(g) \rightarrow 2HCN(g)$; $\Delta H° = +270.3$ kJ/mol

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$; $\Delta H° = -91.8$ kJ/mol

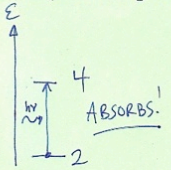
Use Hess's Law to determine $\Delta H°$ for the following equation:

$HCN(g) + 3H_2(g) \longrightarrow CH_4(g) + NH_3(g)$

See Q22, Exam 3A

Q22. [10 pts.] An electron in a hydrogen atom undergoes a transition from $n = 2$ to $n = 4$. Calculate the wavelength of the photon of light emitted/absorbed (state which).

(n_i = 2, n_f = 4)



$$\Delta E = R_H\left(\frac{1}{n_i^2}-\frac{1}{n_f^2}\right) = 2.18\times10^{-18}\,J\left(\frac{1}{2^2}-\frac{1}{4^2}\right) = +4.09\times10^{-19}\,J$$

$$E_{photon} = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.626\times10^{-34}\,J\cdot s \times 3.00\times10^{8}\,m\cdot s^{-1}}{4.09\times10^{-19}\,J}$$

$$= 4.86\times10^{-7}\,m \quad (486\,nm)$$

BONUS Questions:

a) Write the thermochemical equation corresponding to the standard enthalpy of formation of C_2H_3N(g).

$2C(s,graphite) + \frac{3}{2}H_2(g) + \frac{1}{2}N_2(g) \longrightarrow C_2H_3N(g)$

b) Write out the orbital diagram for a nitrogen atom.

$1s^2 2s^2 2p^3$