

LAST NAME:

FIRST NAME:

STUDENT ID:

Chem 206 - GENERAL CHEMISTRY II

MIDTERM EXAMINATION

INSTRUCTIONS: PLEASE READ THIS PAGE WHILE WAITING TO START YOUR EXAM.

- This test includes 4 pages (both sides). Read over the whole test quickly before starting.
- Write answers in the space provided; fill in MCQ answers on the scan sheet in pencil.
- Calculators are permitted; cell phones and other electronic devices are not allowed.
- Potentially useful information is given on back of the (removable) periodic table.
- To earn full points, calculations must include units & explanatory comments.
- You have 70 min to complete the test.
- **GOOD LUCK!**

Mark breakdown:

Page 2. / 16

Page 3. / 14

Page 4. / 12

Page 5. / 10

TOTAL: / 50 (max. = 52)

PERCENT: %

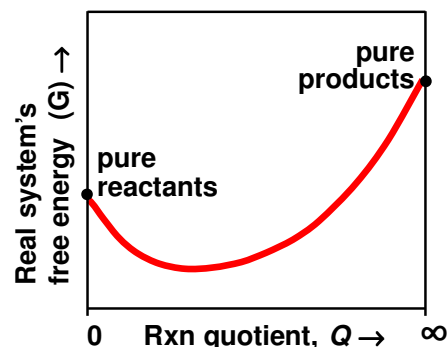
EARNED toward
FINAL GRADE: / 15

PART A: MCQs - MULTIPLE-CHOICE QUESTIONS (2 marks each)

Each question has one correct answer. Put answers in pencil on scan sheet; circle here as a back-up.

Questions #1 – 8 are all independent of each other.

- #1.** Two metals of equal mass with different heat capacities are subjected to the same amount of heat. Which undergoes the smallest change in temperature?
- the metal with the higher specific heat capacity
 - the metal with the lower specific heat capacity
 - both undergo the same change in temperature
 - you need to know the initial temperature of the metals
- #2.** Fill in the blank: If 5.0 kJ of energy is added to a 15.5 g sample of water at 10.0°C, the water is _____.
- completely vaporized
 - frozen solid
 - still a liquid
 - boiling
- #3.** If a student performs an endothermic reaction in a calorimeter, and the heat exchanged with the calorimeter is not taken into account, how would the student's value of ΔH differ from the actual value?
- $\Delta H_{\text{student}}$ would be more negative, because the calorimeter absorbs heat from the reaction.
 - $\Delta H_{\text{student}}$ would be more positive, because the reaction absorbs heat from the calorimeter.
 - $\Delta H_{\text{student}}$ would be less negative, because the calorimeter absorbs heat from the reaction.
 - $\Delta H_{\text{student}}$ would be less positive, because the reaction absorbs heat from the calorimeter.
- #4.** Which one of the following statements about thermodynamics is INCORRECT?
- Heat flow in/out of the system determines ΔS_{surr} , and randomness of the system determines ΔS_{sys} .
 - Spontaneous change occurs in the direction that increases ΔS_{univ} , until equilibrium is reached.
 - Two touching objects reach thermal equilibrium when collisional heat transfer stops entirely.
 - At the same temperature, large molecules have more entropy than small molecules.
- #5.** Fill in the blank: For $\text{H}_2\text{O}(\ell) \rightarrow \text{H}_2\text{O}(\text{g})$ at 298 K at 1.0 atm pressure, ΔH is more positive than ΔE by 2.5 kJ/mol. This quantity of energy can be considered to be _____.
- the difference in the H-O bond energy in $\text{H}_2\text{O}(\ell)$ compared to $\text{H}_2\text{O}(\text{g})$
 - the heat flow required to maintain a constant temperature
 - the work done in pushing back the atmosphere
 - the value of ΔH itself
- #6.** Biologists say that cleaving a phosphate from ATP releases energy for cells to use. How is that possible?
- Hydrolysis of ATP: $\text{ATP}^{4-} + \text{H}_2\text{O} \rightarrow \text{ADP}^{3-} + \text{HPO}_4^{2-} + \text{H}^+$
- creates stronger bonds than it breaks, but decreases entropy by a large amount
 - creates weaker bonds than it breaks, without a compensating change in entropy
 - creates weaker bonds than it breaks, and decreases entropy by a large amount
 - creates stronger bonds than it breaks, and increases entropy significantly
- #7.** Which energy quantity depends on the path followed?
- Gibbs' free energy
 - enthalpy
 - entropy
 - work
- #8.** Which case would yield a real-system free-energy profile like this?
- reactants more stable than reactants ($\Delta G^\circ > 0$)
 - products equally stable as reactants ($\Delta G^\circ = 0$)
 - products more stable than reactants ($\Delta G^\circ < 0$)



- #9.** Which one of the (all true) statements below helps explain why the boiling point of NH_3 (-33°C) is higher than the boiling point of PH_3 (-87.7°C)?
- The polarizability of “hard” NH_3 is significantly smaller than the polarizability of “soft” PH_3 .
 - The dipole moment of NH_3 is extremely large, whereas the dipole moment of PH_3 is tiny.
 - The molecular weight of NH_3 is less than the molecular weight of PH_3 .
 - The van der Waals forces are stronger in $\text{PH}_3(\ell)$ than in $\text{NH}_3(\ell)$.
- #10.** Fill in the blank: The weaker the intermolecular forces in a substance, _____.
- the lower its vapour pressure at a particular temperature
 - the more it deviates from ideal gas behaviour
 - the lower its heat of vaporization
 - the higher its melting point
- #11.** What can you say about the solubility of Vitamin A (shown) in water, and why?
- high solubility, because water makes strong IMFs with Vitamin A's OH that compensate for the many weak IMFs water makes with the rest of Vitamin A's structure
 - low solubility, because water makes strong IMFs with Vitamin A's OH that compensate for the many weak IMFs water makes with the rest of Vitamin A's structure
 - high solubility, because water sacrifices strong IMFs with other water molecules to make weak IMFs with most of Vitamin A's structure
 - low solubility, because water sacrifices strong IMFs with other water molecules to make weak IMFs with most of Vitamin A's structure
-
- #12.** A scuba diver breathes from a high-pressure air tank while diving underwater. What happens to the concentration of oxygen in the diver's blood while diving compared to when breathing on land, and why?
- The $[\text{O}_2]$ is higher, because the tank's higher PO_2 makes gas molecules strike the blood more often.
 - The $[\text{O}_2]$ is lower, because the tank's higher PO_2 makes gas molecules strike the blood more often.
 - The $[\text{O}_2]$ is higher, because the tank's lower PO_2 makes gas molecules strike the blood less often.
 - The $[\text{O}_2]$ is lower, because the tank's lower PO_2 makes gas molecules strike the blood less often.
- #13.** Which of the following statements about the chemistry of real-world phenomena is not true?
- Farmers irrigate to minimize frost damage, because cooling and freezing of water are exothermic.
 - Carbonated beverages lose more of their $\text{CO}_2(\text{g})$ “fizz” when kept cold than when warmed up.
 - Detergents become suspended in water as micelles that can dissolve grease in their cores.
 - Per mole, CaCl_2 is more effective at melting ice on winter roads than NaCl .
- #14.** Why does mercury form an upside-down (concave-down) meniscus in a tube made of glass ($\approx \text{SiO}_2$)?
- d-d forces between hard Hg atoms are stronger than id-id forces between Hg and soft, nonpolar SiO_2
 - d-d forces between hard Hg atoms are weaker than id-id forces between Hg and soft, nonpolar SiO_2
 - id-id forces between soft Hg atoms are stronger than id-d forces between Hg and hard, polar SiO_2
 - id-id forces between soft Hg atoms are weaker than id-d forces between Hg and hard, polar SiO_2
- #15.** If a micro-organism (surrounded by a semi-permeable cell membrane) that normally lives in sea water is placed in fresh water, what will happen?
- Water will flow faster into than out of the organism, and the organism will eventually burst open.
 - Water will flow faster out of than into the organism, and the organism will eventually burst open.
 - Water will flow faster into than out of the organism, and the organism will eventually shrivel up.
 - Water will flow faster out of than into the organism, and the organism will eventually shrivel up.

PART B: SHORT-ANSWER QUESTIONS & CALCULATIONS

Always show full calculations with units and brief comments to clarify the science behind the math.

#16. (10 marks) Consider a solution of 10.0 g LiCl in 150.0 g water (assume complete dissociation of LiCl).

a) **(6 marks)** Determine the vapour pressure above this solution at 45.0°C, given that the vapour pressure of pure water at 45.0°C is 71.93 mm Hg. Show complete calculations.

b) **(4 marks)** Would the LiCl solution boil at a higher or lower temperature than pure water? Explain the molecular-level cause of this difference between solution and pure solvent.

BLANK PAGE – USE FOR ROUGH WORK and/or EXTRA SPACE

POTENTIALLY USEFUL INFORMATION (Note: you are allowed to detach this page.)**Constants:**

$$1 \text{ atm} = 760 \text{ mm Hg} = 760 \text{ torr} = 1.01325 \text{ bar} = 101.325 \text{ kPa}$$

$$R = 8.314 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1} = 0.08206 \text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$$

$$1 \text{ Calorie} = 1 \text{ kcal} = 4.184 \text{ kJ}$$

Data:***Properties of liquid water:***

$$b.p. \text{ (at 1 atm)} = 100.00^\circ\text{C}$$

$$C_{\text{H}_2\text{O}(\ell)} = 4.184 \text{ J}\cdot\text{g}^{-1}\cdot\text{K}^{-1}$$

$$\Delta H_{\text{vap}}^\circ = 40.7 \text{ kJ}\cdot\text{mol}^{-1}$$

$$d_{\text{H}_2\text{O}(\ell)} \text{ (at } 25^\circ\text{C)} = 1.00 \text{ g}\cdot\text{mL}^{-1}$$

$$K_f \text{ H}_2\text{O} = 1.86 \text{ }^\circ\text{C}\cdot\text{kg}\cdot\text{mol}^{-1}$$

$$K_b \text{ H}_2\text{O} = 0.52 \text{ }^\circ\text{C}\cdot\text{kg}\cdot\text{mol}^{-1}$$

$$P^\circ_{(298 \text{ K})} = 23.8 \text{ mm Hg}$$

Properties of ice:

$$m.p. \text{ (at 1 atm)} = 0.00^\circ\text{C}$$

$$C_{\text{H}_2\text{O}(\text{s})} = 2.06 \text{ J}\cdot\text{g}^{-1}\cdot\text{K}^{-1}$$

$$d_{\text{H}_2\text{O}(\text{s})} = 0.917 \text{ g}\cdot\text{mL}^{-1}$$

$$\Delta H_{\text{fus}}^\circ = 6.02 \text{ kJ}\cdot\text{mol}^{-1}$$

Formulae:

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G^\circ = -RT \ln K_{\text{eq}}$$

$$C = k P \quad (\text{or, } S = k P)$$

$$P = \chi P^\circ$$

$$\Delta T = Km$$

$$\pi V = nRT$$

Periodic Table of the Elements

1 H 1.008																	18 He 4.00
2 Li 6.941	3 Be 9.012											13 B 10.81	14 C 12.01	15 N 14.007	16 O 15.999	17 F 18.998	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	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 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 (97.91)	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 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	La-Lu	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po 208.98	85 At 209.99	86 Rn 222.02
87 Fr 223	88 Ra 226.03	Ac-Lr	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)									

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (245)	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)

Electronegativity Values of the Elements

H 2.1																	He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe
Cs 0.7	Ba 0.9	La-Lu	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2	Rn