GENERAL CHEMISTRY II
MIDTERM TEST

Note to students:
This exam covered Ch.6, 9.8, 19.1-19.6, 13.1-13.5, 14 & 15.1-15.3.

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

This test paper includes 4 pages (both sides); some potentially useful information is given on back of the periodic table. Check that your paper is complete before starting. You can remove the periodic table if you wish. Answer all questions inside the space provided. Calculators are permitted; cell phones and electronic dictionaries are not allowed. You have 75 min to complete the test. *I suggest you scan the whole test quickly before starting & do the 'easy' stuff 1st.*
GOOD LUCK! *Suggestion: spend 1 min / mark ⇨ 25 min left to finish uncertain problems & check.*

LAST NAME: _____ FIRST NAME: _____

STUDENT NUMBER: _____

Mark breakdown:

Page 2.	/ 10
Page 3.	/ 11
Page 4.	/ 10
Page 5.	/ 10
Page 6.	/ 10
TOTAL:	/ 50 (max. = 51)
PERCENT:	%
EARNED toward FINAL GRADE:	/ 20

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 # 1. (__/ 10 marks) ***True or False?*** **Circle T or F to correctly describe each statement; you do not need explain your answers.**

T / F A solution containing an ionic compound will have a lower vapour pressure than a solution containing the same concentration of a molecular compound.

T / F Parts-per-million is a concentration unit based on molar quantities of solvent and solute.

T / F Increasing molecular mass often correlates with increasing intermolecular forces, because induced-dipole / induced-dipole interactions are influenced by the number and size of atoms present in the molecules.

T / F When a gas-forming reaction occurs in a system, the system gains energy by doing work.

T / F At higher elevations, where the atmospheric pressure is lower, it takes longer to cook foods in boiling water because the boiling point of water is below 100°C.

T / F According to the second law of thermodynamics, a spontaneous change is accompanied by a decrease in the free energy of the system.

T / F Hydrophobic substances are not very soluble in water because the London dispersion forces between the hydrophobic molecules are much stronger than the dipole–induced-dipole interactions between the water and the hydrophobic molecules.

T / F The vapour pressure above a mixture of two volatile liquids depends only on the vapour pressure of the liquid that is more volatile.

T / F A reaction will be endothermic if it involves forming products with overall weaker bonds than the bonds in the reactants.

T / F In general, if you study a reaction or process using a constant-volume (“bomb”) calorimeter, the temperature change you measure will allow you to calculate the enthalpy change for your system.

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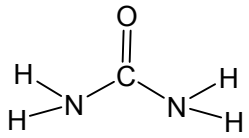
 # 2. (__/ 11 marks) Urea (NH_2CONH_2) is an important nitrogen-based fertilizer that is produced industrially by the reaction: $2\ NH_{3(g)} + CO_{2(g)} \rightarrow NH_2CONH_{2(aq)} + H_2O_{(l)}$

a) **(3 marks)** Aqueous urea is the product of this reaction. Explain why urea (shown below) is soluble in water; be sure to clearly identify (name AND sketch) the relevant intermolecular forces.



b) **(6 marks)** Is the reaction of ammonia and carbon dioxide to produce aqueous urea thermodynamically favourable at 298 K? Show all necessary calculations.

Substance (at 298 K)	ΔH^o_f (kJ/mol)	S^o_f (J/mol·K)
$NH_{3(g)}$	-45.90	192.77
$CO_{2(g)}$	-393.51	213.74
$NH_2CONH_{2(aq)}$ *	-317.1	172.8
$H_2O_{(l)}$	-285.83	69.95
*(* Data adapted for the purpose of this exam.)*		

c) **(2 marks)** Would this reaction give a higher yield of products at higher temperatures or at lower temperatures? Explain your choice.

 # 3. (__/ 10 marks) Ethylene glycol ($HOCH_2CH_2OH$) is commonly used as an antifreeze. Pure ethylene glycol is a liquid with a density of 1.11 g/mL.

a) **(6 marks)** What volume (in L) of ethylene glycol would you add to a car radiator containing 6.50 L of water if the coldest winter temperature expected is -35°C? *[See helpful data on formula page….]*

b) **(4 marks)** Provide a detailed explanation of what causes a solution to have a lower freezing point than pure water. *[Point form is ok.]*

 # 4. (__/ 10 marks) Glauber's salt, $Na_2SO_4 \cdot 10H_2O$ (322.195 g/mol), melts at a convenient temperature of 32°C. Home-builders sometimes place plastic bags containing Glauber's salt in the ceilings of rooms to help regulate the temperature. During the day, the melting process absorbs heat from the room, and at night, the freezing process releases heat.

$$Na_2SO_4 \cdot 10H_2O_{(s)} \rightarrow Na_2SO_4 \cdot 10H_2O_{(l)} \qquad \Delta H^\circ = 74.4 \text{ kJ/mol}$$

a) **(5 marks)** How much heat must the air in a room lose for its temperature to drop by 8.2°C?
Assume: (1) room's dimensions = 2.80 m x 10.6 m x 17.2 m. Note: 1 L = 1 dm^3
(2) constant air density of 1.294 g/L; air's specific heat capacity = 1.2 J/(g°C).

b) **(3 marks)** What mass of Glauber's salt (in kg) is required to absorb the quantity of heat from (a)?

c) **(2 marks)** In general, is the cooling of air an entropically favourable or entropically unfavourable process (according to the air)? Explain.

 # 5. (__/ 6 marks) The osmotic pressure of human blood at body temperature (37°C) is 7.7 atm. If a solution containing equal concentrations of glucose ($C_6H_{12}O_6$) and sodium chloride (NaCl) is to be safely administered to a person intravenously, what must be the concentration (in molarity) of each substance?

 # 6. (__/ 4 marks) The reaction shown at right was studied at -10°C: The rate was determined by monitoring the Cl_2 concentration; the experimental data is shown in the table.

$2\ NO_{(g)} + Cl_{2(g)} \rightarrow 2\ NOCl_{(g)}$

$[NO]_o$ (mol/L)	$[Cl_2]_o$ (mol/L)	Initial rate (mol/L·min)
0.10	0.10	0.18
0.10	0.20	0.36
0.20	0.20	1.45

a) **(2.5 marks)** What is the rate law for this reaction?

b) **(1.5 marks)** What is the rate constant at this temperature? *(You do not need to find the average.)*

POTENTIALLY USEFUL INFORMATION

Constants:

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

1 atm = 760 mm Hg = 760 torr = 101.325 kPa

Data:

Properties of liquid water:

bp (at 1 atm) = 100.00°C

$C_{H_2O(l)} = 4.184\ J \cdot g^{-1}K^{-1}$

$d_{H_2O(l)} = 1.00\ g \cdot mL^{-1}$

$K_{f\ H_2O} = 1.86\ °C \cdot kg \cdot mol^{-1}$

$K_{b\ H_2O} = 0.52\ °C \cdot kg \cdot mol^{-1}$

Properties of solid water:

mp (at 1 atm) = 0.00°C

$C_{H_2O(s)} = 2.06\ J \cdot g^{-1}K^{-1}$

$d_{H_2O(s)} = 0.917\ g \cdot mL^{-1}$

Formulae:

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

$PV = nRT$

$C = k\ P$ (or, $S = k\ P$)

$P = \chi\ P^o$

$\Delta T = K\ m$