Chemistry 141 Name

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Exam 2a October 21, 2010

 Multiple Choice (30 points)

 Page 4 (5 points)

 Page 5 (10 points)

 Page 6 (18 points)

 Page 7 (9 points)

 Page 8 (16 points)

 Page 9 (16 points)

 Page 10 (12 points)

 Total (116 points)

 Percent (100 %)

All work must be shown to receive credit. Give all answers to the correct number of significant figures

Avogadros number = 6.022 x 1023 /mol

4 quarts = 1 gallon

36 in = 1 yard

* specific heat of ice 2.06 J/goC 37.1 J/moloC
* specific heat of water 4.184 J/goC 75.4 J/moloC
* specific heat of steam 2.0 J/goC 36 J/moloC
* heat of fusion 333 J/g 6.01 kJ/mol
* heat of vaporization 2260 J/g 40.7 kJ/mol

Grossmont College

Periodic Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  IA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | VIIA | NOBLE GASES |
| 1**H**1.008 | IIA |  |  |  |  |  |  |  |  |  |  | IIIA | IVA | VA | VIA | 1**H**1.008 | 2**He**4.002 |
| 3**Li**6.941 | 4**Be**9.012 |  |  |  |  |  |  |  |  |  |  | 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**23.00 | 12**Mg**24.30 | IIIB | IVB | VB | VIB | VIIB |  VIII VIII VIII | IB | IIB | 13**Al**27.00 | 14**Si**28.09 | 15**P**30.97 | 16**S**32.06 | 17**Cl**35.45 | 18**Ar**39.95 |
| 19**K**39.10 | 20**Ca**40.08 | 21**Sc**44.96 | 22**Ti**47.90 | 23**V**50.94 | 24**Cr**52.00 | 25**Mn**54.94 | 26**Fe**55.85 | 27**Co**58.93 | 28**Ni**58.70 | 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 |
| 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**(99) | 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 |
| 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**209.0 | 84**Po**(209) | 85**At**(210) | 86**Rn**(222) |
| 87**Fr**(223) | 88**Ra**226.0 | 89**Ac**227.0 | 104**Rf**(261) | 105**Db**(262) | 106**Sg**(263) | 107**Bh**(262) | 108**Hs**(265) | 109**Mt**(266) | 110**??**(269) |  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 58**Ce**140.1 | 59**Pr**140.9 | 60**Nd**144.2 | 61**Pm**(147) | 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**231.0 | 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) |

Lanthanide series

Actinide series

Part I – Multiple Choice (30 points)

1. Thermochemistry is the study of how \_\_\_\_\_\_\_\_ is produced and consumed during chemical reactions.
	1. heat
	2. energy
	3. temperature
	4. work
2. A student dissolving some ammonium nitrate (NH4NO3) in water notices that the beaker gets cooler as the solid dissolves. This is an example of a(n)
	1. exothermic process.
	2. combustion reaction.
	3. endothermic process.
	4. thermodynamic cycle.
3. A group of thermochemical reactions, with known enthalpies (Δ*H*rxn), can be used to determine the enthalpy of an unknown reaction since
	1. Δ*H* is path dependent.
	2. Δ*H* is an extensive property.
	3. Δ*H* is independent of path.
	4. Δ*H* is an intensive property.
4. If the enthalpy change in a system is negative, then
	1. the enthalpy change in the surroundings is negative.
	2. the enthalpy change in the surroundings is positive.
	3. the total enthalpy of the universe increases.
	4. the total energy of the universe decreases.



1. The heating curve for a substance is shown in the following graph. The substance is initially a solid, heated to a liquid, and finally converted to a gas. Which of the line segments represents the *solid* → liquid phase transition?
	1. a
	2. b
	3. c
	4. d
2. A 15 g piece of iron (*C*p = 25.09 J/K · mol) is heated to a temperature of 95°C and placed into a bucket containing 4.5 gal of water (*C*p = 75.38 J/K · mol), initially at 25°C. Eventually,
	1. the water will be warmer than the iron.
	2. the iron will be warmer than the water.
	3. the iron will be colder than the water.
	4. the iron and the water will be at the same temperature.
3. Which of the following substances would be the best choice to use as an insulator?
	1. CCl2F2 (?) (*C* = 0.598 J/K · g)
	2. olive oil (*C* = 1.97 J/K · g)
	3. CCl2F2 (*g*) (*C* = 1.047 J/K · g)
	4. Hg () (*C* = 0.1393 J/K · g)
4. Which of the following substances will require the highest column for measuring an atmospheric pressure of 0.950 atm? (Assume all the barometers have columns with the same diameter.)
	1. Mercury (*d* = 13.59 g/cm3)
	2. Ethylene glycol (*d* = 1.09 g/cm3)
	3. Ethanol (*d* = 0.79 g/cm3)
	4. Water (*d* = 1.00 g/cm3)
5. The pressure of a gas is inversely proportional to
	1. the volume of the gas.
	2. the temperature of the gas.
	3. the number of gas particles.
	4. the mass of the gas.
6. A car tire is inflated to 32.0 lb/in2 at sea level and then driven to an elevation of 5000 ft above sea level, where the driver discovers the tire pressure is 32.1 lb/in2 after allowing the tires to cool. If the driver could check it, she would discover that the volume of the tire’s inner tube has
	1. decreased.
	2. remained the same.
	3. increased.
	4. halved.
7. A gas at 3.0 atm is contained in a metal cylinder. Assuming the volume of the cylinder does not change with temperature, at which temperature are the gas molecules moving the fastest (on average)?
	1. *T* = 100°C
	2. *T* = 75°C
	3. *T* = 25°C
	4. *T* = 10°C
8. In an ideal gas,
	1. the gas molecules do not interact.
	2. the gas molecules’ volumes are negligible.
	3. gas molecules do not interact, and their volumes are negligible.
	4. gas molecules interact, but their volumes are negligible.
9. Which of the following is unimportant when using the ideal gas law?
	1. the chemical identity of the gas sample
	2. the temperature of the gas sample
	3. the pressure of the gas sample
	4. the volume of the container holding the gas sample
10. The pressure in a container holding N2, He, CH4, and Ar is increased, and the densities of the four gases are monitored. Which curve is for N2?
	1. a
	2. b
	3. c
	4. d
11. The partial pressure of a gas is
	1. the pressure a gas exerts in its pure state.
	2. the pressure due to a gas in a mixture.
	3. the same as the gas’s vapor pressure.
	4. the total pressure of a mixture of gases.

Part 2 - Problems

1. (5 points) A system receives 425 J of heat and delivers 535 J of work to its surroundings. What is the change in internal energy of the system (in J)?

q = +425 J

w = -535 J

E = q + w = +425J + -535J = -110J

1. (5 points) A chemical engineer studying the properties of fuels placed 1.750 g of a hydrocarbon in the bomb of a calorimeter and filled it with O2 gas. The bomb was immersed in 2.500 L of water and the reaction initiated. The water temperature rose from 20.00oC to 25.41oC. If the calorimeter (excluding the water) had a heat capacity of 403 J/K, what was the heat of combustion per gram of fuel?

heat evolved by hydrocarbon = heat gained by water + heat gained by calorimeter

 $= \left(2500 g\right)\left(\frac{4.184 J}{g ℃}\right)\left(5.41℃\right)+\left(\frac{403 J}{℃}\right)\left(5.41℃\right)$

$$=56600 J+2180 J$$

$$=58800 J$$

heat of combustion per gram

$$\frac{58800 J}{1.750 g}={33600 J}/{g} or {33.6 kJ}/{g}$$

1. (5 points) An important industrial route to extremely pure acetic acid is the reaction of methanol with carbon monoxide:



Use bond energies to calculate the heat of reaction.

|  |  |  |  |
| --- | --- | --- | --- |
| break |  | form |  |
| C-O  | +351 kJ | C-C  | -347 kJ |
| C≡O | +1070 kJ | C=O | -741 kJ |
|  |  | C-O | -351 kJ |
|  | +1421 kJ |  | -1439 kJ |

Overall energy change -18 kJ

1. (18 points) Kerosene, a common space heater fuel, is a mixture of hydrocarbons whose “average” formula is C12H26.
	1. Write a balanced equation, using the simplest whole-number coefficients, for the complete combustion of kerosene to gases.

2 C12H26*(l)* + 37 O2*(g)* 🡪 24 CO2*(g)* + 26 H2O*(g)*

* 1. If ΔHocomb (kerosene) = -1.5000 x 104 kJ for the equation as written in part (a), determine ΔHof of kerosene.

$$∆H\_{rxn}=24\left(∆H\_{f}CO\_{2},g\right)+26\left(∆H\_{f}H\_{2}O,g\right)-2\left(∆H\_{f}C\_{12}H\_{26},l\right)$$

$$-15000 kJ=24\left(-393.5 kJ\right)+26\left(-241.8 kJ\right)-2\left(∆H\_{f}C\_{12}H\_{26},l\right)$$

$$-15000 kJ=-9444 kJ+ -6287 kJ-2\left(∆H\_{f}C\_{12}H\_{26},l\right)$$

$$-15000 kJ+9444 kJ+6287 kJ=-2\left(∆H\_{f}C\_{12}H\_{26},l\right)$$

$$+731 kJ=-2\left(∆H\_{f}C\_{12}H\_{26},l\right)$$

$$∆H\_{f}C\_{12}H\_{26},l= -366 kJ$$

* 1. Calculate the heat produced by combustion of 0.5000 L of kerosene (density of kerosene = 0.749 g/mL)

$$?q=0.50 L C\_{12}H\_{26}×\frac{1000 mL}{1 L}×\frac{0.749 g C\_{12}H\_{26}}{1 mL}×\frac{1 mol C\_{12}H\_{26}}{170.4 g C\_{12}H\_{26}}×\frac{-15000 kJ}{2 mol C\_{12}H\_{26}}=-16480 kJ$$

So, 16480 kJ of energy were produced!

* 1. If the heat produced by the kerosene is used to heat a block of ice with a mass of 25.00 kg at -20.0oC, what will be the state of the products and the temperature? If there is more than one state present, indicate the mass of each state present.

$$?heat to warm ice to 0℃=\left(25.0 kg\right)\left(\frac{1000g}{1 kg}\right)\left(\frac{2.06 J}{g ℃}\right)\left(\frac{1kJ}{1000J}\right)\left(20.0℃\right)=1030 kJ$$

heat remaining = 16480 kJ – 1030 kJ = 15450 kJ

$$?heat to melt ice at 0℃=\left(25.0 kg\right)\left(\frac{1000g}{1 kg}\right)\left(\frac{333 J}{1 g}\right)\left(\frac{1kJ}{1000J}\right)=8330 kJ$$

heat remaining = 15450 kJ – 8330 kJ = 7130 kJ

$$?heat to warm water from 0℃ to 100℃=\left(25.0 kg\right)\left(\frac{1000g}{1 kg}\right)\left(\frac{4.184 J}{g ℃}\right)\left(\frac{1kJ}{1000J}\right)\left(100.0℃\right)=10460 kJ$$

heat remaining = 7130 kJ – 10460 kJ = a negative number

We do not have enough energy to heat all of the water to 100oC, lets find out what the temperature will be—

$$7130 kJ= \left(25.0 kg\right)\left(\frac{1000g}{1 kg}\right)\left(\frac{4.184 J}{g ℃}\right)\left(\frac{1kJ}{1000J}\right)\left(∆T℃\right)$$

$$∆T=\frac{\left(7130 kJ\right)g℃}{\left(4.184 J\right)\left(25.0 kg\right)}=68.1℃$$

So the final temperature of the water will be 68.1 oC.

1. (9 points) What is the effect of the following on the volume of 1 mol of an ideal gas?
	1. Half the gas escapes through a stopcock (at constant P and T).

The volume will decrease because volume is directly proportional to the number of moles of gas. Moles of gas decrease so volume decreases.

* 1. The temperature is decreased from 700K to 350 K (at constant P)

The volume will decrease because volume is directly proportional to temperature at constant pressure. Temperature decreases so volume decreases.

* 1. The pressure is increased from 2 atm to 8 atm (at constant T).

The volume will decrease because volume is inversely proportional to pressure at constant temperature. Pressure increases so volume decreases.

1. (5 points) A sample of sulfur hexafluoride gas occupies a volume of 5.10 L at 198oC. Assuming that the pressure remains constant, what temperature (in oC) is needed to reduce the volume to 2.50 L?

$$PV=nRT \rightarrow \rightarrow \rightarrow R=\frac{PV}{nT}=\frac{P\_{1}V\_{1}}{n\_{1}T\_{1}}=\frac{P\_{2}V\_{2}}{n\_{2}T\_{2}}$$

$$If P and n remain constant$$

$$\frac{V\_{1}}{T\_{1}}=\frac{V\_{2}}{T\_{2}}\rightarrow \rightarrow T\_{2}=T\_{1}\left(\frac{V\_{2}}{V\_{1}}\right)=471 K\left(\frac{2.50 L}{5.10 L}\right)=231 K or-42℃$$

1. (5 points) A 75.0 g sample of dinitrogen monoxide is confined in a 3.10 L vessel. What is the pressure (in atm) at 115oC?

$$PV=nRT \rightarrow \rightarrow \rightarrow P=\frac{nRT}{V}=\frac{\left(1.70 mol\right)\left(0.0821 L atm\right)\left(388K\right)}{\left(3.10 L\right)mol K}=17.5 atm$$

$$?mol N\_{2}O=75.0 g N\_{2}O×\frac{1 mol N\_{2}O}{44.02 g N\_{2}O}=1.70 mol N\_{2}O$$

1. (6 points) When an evacuated 63.8 mL glass bulb is filled with a gas at 22oC and 747 mm Hg, the bulb gains 0.103 g in mass. Is the gas N2, Ne, or Ar?

$$?molar mass= \frac{mass gas}{mol gas}=\frac{0.103 g }{0.00259 mol}=39.8{g}/{mol or argon}$$

$$PV=nRT \rightarrow \rightarrow \rightarrow n=\frac{PV}{RT}=\frac{\left(747 torr\right)\left(0.0638 L\right)mol K}{\left(62.4 L torr\right)\left(295K\right)}=0.00259 mol gas$$

1. (6 points) “Strike anywhere” matches contain the compound tetraphosphours trisulfide, which burns to form tetraphosphorus decaoxide and sulfur dioxide gas. How many milliliters of sulfur dioxide, measured at 725 torr and 32oC can be produced from burning 0.800 g of tetraphosphorus trisulfide?

P4S3 + O2 🡪 P4O10 + 3 SO2

$$?mol SO\_{2}=0.800 g P\_{4}S\_{3}×\frac{1 mol P\_{4}S\_{3}}{220.1 g P\_{4}S\_{3}}×\frac{3 mol SO\_{2} }{1 mol P\_{4}S\_{3}}=0.0109 mol SO\_{2}$$

$$PV=nRT \rightarrow \rightarrow \rightarrow V=\frac{nRT}{P}=\frac{\left(62.4 L torr\right)\left(295K\right)\left(0.0109 mol\right) }{\left(725 torr\right)mol K}=0.277 L or 277 mL SO\_{2}$$

1. ( points) Consider two 1 L samples of gas: one is H2 and the other is O2. Both are at 1 atm and 25oC. How do the samples compare in terms of
	1. Mass

The oxygen sample will have greater mass. Same number of molecules, more mass per molecule means more mass.

* 1. Density

Oxygen will be more dense. More mass, same volume means higher density.

* 1. Average molecular kinetic energy

Average kinetic energy will be the same. Same temperature means same kinetic energy.

* 1. Average molecular speed

Hydrogen molecule will have higher average molecular speed. Same energy, lower mass means faster particles.

* 1. Time for a given fraction of molecules to effuse

Oxygen will take longer to effuse. Slower molecules means longer effusion time.

1. (7 points) Solid white phosphorus melts and then vaporizes at high temperature. Gaseous white phosphorus effuses at a rate that is 0.404 times that of neon in the same apparatus under the same conditions. How many atoms are in a molecule of gaseous white phosphorus?

$$\frac{rate\_{Ne}}{rate\_{?}}=\sqrt{\frac{MW\_{?}}{MW\_{Ne}}}$$

$$\frac{rate\_{Ne}}{0.404\left(rate\_{Ne}\right)}=\sqrt{\frac{MW\_{?}}{{20.18 g}/{mol}}}$$

$$\left(\frac{1}{0.404}\right)^{2}=\frac{MW\_{?}}{{20.18 g}/{mol}}$$

$${20.18 g}/{mol}\left(\frac{1}{0.404}\right)^{2}=MW\_{?}=124 {g}/{mol}$$

$$\frac{124 g P }{mol P\_{?}}×\frac{1 mol P}{30.97 g P}=\frac{4 mol P}{mol P\_{?}}$$

So formula is P4

1. (5 points) At a height of 300 km above Earth’s surface, an astronaut finds that the atmospheric pressure if about 10.8 mmHg and the temperature is 500K. How many molecules of gas are there per milliliter at this altitude?

$$PV=nRT \rightarrow \rightarrow \rightarrow \frac{n}{V}=\frac{P}{RT}$$

$$\frac{? molec}{mL}=\frac{mol}{L}×\frac{6.022 ×10^{23}molec}{mol}×\frac{L}{1000 mL}$$

$$=\frac{P}{RT}×\frac{6.022 ×10^{23}molec}{mol}×\frac{L}{1000 mL}$$

$$=\frac{\left(10.8 torr\right)mol K}{\left(62.4 L torr\right)\left(500K\right)}×\frac{6.022 ×10^{23}molec}{mol}×\frac{L}{1000 mL}$$

$$=\frac{2.08 ×10^{17}molec}{mL}$$