General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Autumn 2023

November 9, 2023

Exam # 3 A

Name _____

Please print your full name, and the exam version (3 A) that you have on the scantron sheet!
(Bubble in the best answer choice for each question on the scantron sheet in pencil!)

Please ☑ check the box next to your correct section number.

Section #:

- ❒ 1. (Mon Lab, 11:10 AM – 1:55 PM)
- ❒ 2. (Wed Lab, 11:10 AM – 1:55 PM)

} **Fleeman**

- ❒ 3. (Tue Lab, 11:00 AM – 1:50 PM)
- ❒ 4. (Thu Lab, 11:00 AM – 1:50 PM)

} **Napper**

Multiple Choice:	_____	**/ 50**
Q21:	_____	**/ 10**
Q22:	_____	**/ 10**
Q23:	_____	**/ 10**
Q24:	_____	**/ 10**
Q25:	_____	**/ 10**
BONUS:	_____	**/ 3**
TOTAL:	_____	**/ 100**

Each problem in this section (multiple choice) is worth 2.5 points!

Q1. 0.20 mol of nitrogen is mixed with 0.40 mol of argon at STP. If the total pressure is 1.20 atm, what must the partial pressure of argon be?

A) 0.20 atm

B) 0.40 atm

C) 0.60 atm

D) 0.80 atm

$P_{Ar} = X_{Ar} \cdot P_{TOT}$

$X_{Ar} = \frac{0.40\,mol\ (n_{Ar})}{0.60\,mol\ (n_{TOT})} = 0.67$

$\rightarrow P_{Ar} = 0.67 \times 1.20\,atm = 0.80\,atm$

Q2. Gases can be modeled as being composed of tiny, constantly moving particles—which collide with each other and exchange energy. The pressure of the gas arises from collisions with the walls. This is known as:

A) The ideal gas law

B) The Boltzmann postulate

C) The kinetic molecular theory

D) The van der Waals hypothesis

Q3. Real gases differ from ideal gases in that the particles:

A) are moving at different speeds depending upon their absolute temperature

B) are composed of molecules that can contain more than one atom

C) have motion that is affected by the molar mass of the gas

D) have both size and attractions to one another

Q4. Potential energy is energy by virtue of

A) speed

B) position

C) size

D) temperature

Q5. An isolated system is:

A) not able to exchange matter or energy with its surroundings

B) able to exchange matter but not energy with its surroundings

C) not able to exchange matter, but can exchange energy with its surroundings

D) able to exchange both matter and energy with its surroundings

Q6. A 10.0 g sample of aluminum with a temperature of 14.0 °C has a specific heat of 0.90 J/g·°C. If it loses 42 J of heat, what will its new temperature be?

A) −33.2 °C

B) 4.7 °C

C) 9.3 °C

D) 19.4 °C

$q = mc\Delta t$

$\rightarrow \Delta t = \frac{q}{mc} = \frac{-42\,J}{10.0\,g \times 0.90\,J/g\cdot°C}$

$= -4.7°C$

$\rightarrow t_F = t_I + \Delta t = 14.0°C - 4.7°C = 9.3°C$

Q7. For the thermochemical equation: $2\,SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$; $\Delta H = -198.2$ kJ/mol calculate q if 15.0 g of $SO_2(g)$ reacts.

A) +11.6 kJ

B) −46.4 kJ

C) +99.1 kJ

D) −23.2 kJ

$15.0\,g\,SO_2 \times \frac{1\,mol\,SO_2}{64.07\,g\,SO_2} \times \frac{-198.2\,kJ}{2\,mol\,SO_2} = -23.2\,kJ$

Q8. Graphite and diamond are two different *forms* of the element carbon. A more precise description would refer to them as:

A) isotopes

B) allotropes

C) isomers

D) allosters

Q9. Electromagnetic waves with a frequency of 3.7×10^8 Hz have a wavelength of:

A) 8.1×10^{15} m

B) 810 nm

C) 81 µm

D) 0.81 m

$c = \nu\lambda$

$\rightarrow \lambda = c/\nu = \frac{3.00 \times 10^8\,m/s}{3.7 \times 10^8\,/s} = 0.81m$

Q10. Which set of four quantum numbers is impossible for an electron in an atom?

A) $n = 4, l = 1, m_l = -3, m_s = -\frac{1}{2}$

B) $n = 3, l = 2, m_l = -2, m_s = +\frac{1}{2}$

C) $n = 2, l = 1, m_l = 1, m_s = -\frac{1}{2}$

D) $n = 1, l = 0, m_l = 0, m_s = -\frac{1}{2}$

m_ℓ: $-\ell, \ldots, 0, \ldots, +\ell$!

Q11. All of the following have a standard heat of formation, ΔH°_f, value of zero at 25 °C and 1.0 atm **except:**

A) $Cl_2(g)$

B) Fe(s)

C) H(g)

D) Ne(g)

Q12. The change of enthalpy in an exothermic reaction is

A) positive

B) negative

C) constant

D) none of the above

Q13. Which statement about the following reaction is correct?

$$2\ Fe(s) + 3\ CO_2(g) \longrightarrow Fe_2O_3(s) + 3\ CO(g) \quad \Delta H = 26.6\ kJ/mol$$

A) 26.6 kJ of heat is absorbed for every 2 mol of Fe reacted

B) 26.6 kJ of heat is released for every 3 mol of CO_2 reacted

C) 26.6 kJ of heat is released for every 3 mol of CO produced

D) 13.3 kJ of heat is absorbed for every 3 mol of CO_2 reacted

Q14. What is a possible set of quantum numbers that describe a 3p orbital?

A) $n = 3, l = 1, m_l = 1, m_s = -\frac{1}{2}$

B) $n = 3, l = 2, m_l = 1, m_s = -\frac{1}{2}$

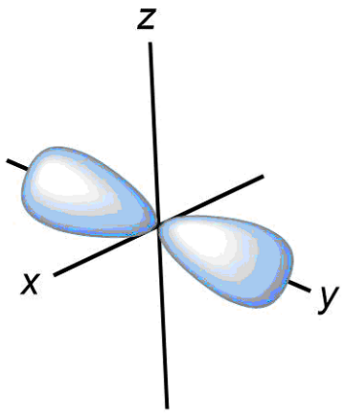
C) $n = 3, l = 3, m_l = 1, m_s = -\frac{1}{2}$

D) $n = 3, l = 1, m_l = -3, m_s = -\frac{1}{2}$

n ; $\ell = 1$

code: s p d f
ℓ: 0 1 2 3

Q15. What type of atomic orbital is represented below?



A) s

B) p

C) d

D) f

Q16. Which of the following is true about frequency and wavelength of electromagnetic waves?

A) as frequency increases, wavelength decreases

B) as frequency increases, wavelength increases

C) frequency is a constant for all wavelengths

D) frequency and wavelength are independent of each other

Q17. Which statement is true about the ground state and the excited state of an electron in an atom?

A) the ground state is the highest energy level of an electron

B) the ground state is the lowest energy level of an electron

C) the ground state is further from the nucleus than the excited state

D) when an electron goes from the excited state to the ground state it absorbs light

Q18. Which color of visible light has the smallest frequency?

A) blue

B) green

C) violet

D) red

Q19. The amount of heat needed to raise the temperature of one gram of a substance by one degree Celsius is referred to as:

A) heat capacity

B) specific heat

C) calorimetry

D) enthalpy

Q20. The reaction that represents the standard enthalpy of formation, ΔH°_f, for liquid acetone, CH_3COCH_3, is:

A) $CH_3COCH_3(l) \longrightarrow 3\ C(graphite) + 3\ H_2(g) + \frac{1}{2}\ O_2(g)$

B) $6\ C(graphite) + 6\ H_2(g) + O_2(g) \longrightarrow 2\ CH_3COCH_3(l)$

C) $3\ C(graphite) + 3\ H_2(g) + \frac{1}{2}\ O_2(g) \longrightarrow CH_3COCH_3(l)$

D) $CH_3COCH_3(l) + 4\ O_2(g) \longrightarrow 3\ CO_2(g) + 3\ H_2O(g)$

Each problem in this section (short answer) is worth 10 points!

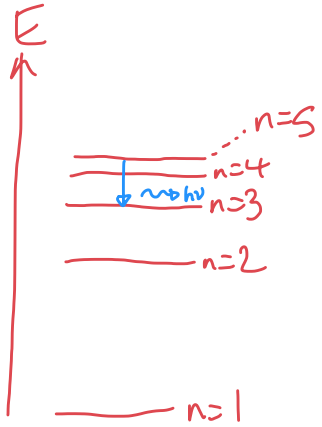
All work must be shown to receive credit!

You must use the factor–label (conversion–factor) method for all conversions!

Be sure to include units where applicable!

All numeric answers must be rounded to the correct number of significant figures!

Q21. (a) A hydrogen atom undergoes a transition from $n = 5$ to $n = 3$. Calculate both the frequency and wavelength of light absorbed / emitted (state which).



This will be an emission process as atom loses E in form of a photon (particle of light)

$$\Delta E = E_3 - E_5 = -R_H\left(\frac{1}{3^2} - \frac{1}{5^2}\right) = -1.55\times10^{-19}\ \text{J}$$

($R_H = 2.18\times10^{-18}$ J)

$$E_{photon} = |\Delta E| = 1.55\times10^{-19}\ \text{J}$$

$$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E} = \frac{6.626\times10^{-34}\ \text{J·s} \times 3.00\times10^{8}\ \text{m/s}}{1.55\times10^{-19}\ \text{J}}$$

$$= 1.28\times10^{-6}\ \text{m} \quad (1.28\ \mu\text{m})$$

ν? either $E = h\nu$, $\nu = \frac{E}{h} = \ldots$ or $c = \nu\lambda$, $\nu = c/\lambda = \frac{3.00\times10^{8}\ \text{m/s}}{1.28\times10^{-6}\ \text{m}} = 2.34\times10^{14}\ \text{s}^{-1}$ or Hz

(b) Without performing a calculation, write down a transition that would lead to a **longer** wavelength of light than the one described in part (a). Explain your answer.

$E = \frac{hc}{\lambda}$. $\lambda\uparrow$ $E\downarrow$ $\Rightarrow$ $n=4 \rightarrow n=3$

or $n=5 \rightarrow n=4$ etc.

would be longer λ.

Q22. (a) Write down the chemical reaction that corresponds to ΔH_f^o for $C_3H_7OCl(l)$.

form 1 mole from its elements in most stable form

$$3C(s,\text{graphite}) + \tfrac{7}{2}H_2(g) + \tfrac{1}{2}O_2(g) + \tfrac{1}{2}Cl_2(g) \rightarrow C_3H_7OCl(l)$$

(b) Given the following chemical equations:

1. $S(s) + O_2(g) \rightarrow SO_2(g)$ reverse $\Delta H = -275$ kJ/mol $\times -1$
2. $2\,S(s) + 3\,O_2(g) \rightarrow 2\,SO_3(g)$ $\times \frac{1}{2}$ $\Delta H = -945$ kJ/mol $\times 1/2$

Calculate ΔH for:

$SO_2(g) + \frac{1}{2}\,O_2(g) \rightarrow SO_3(g)$

Be sure to explain your work!

(1) $SO_2(g) \rightarrow S(s) + O_2(g)$; $\Delta H = +275$ kJ/mol

(2) $S(s) + \frac{3}{2}O_2(g) \rightarrow SO_3(g)$; $\Delta H = -473$ kJ/mol

$SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$; $\Delta H = -198$ kJ/mol

Q23. Find the final temperature of an aluminum/water mixture when 10.0 grams of aluminum at 130.0 °C mixes with 200.0 g of water at 25.0 °C. The specific heat of aluminum is 0.900 J/g•°C and the specific heat of water is 4.184 J/g•°C. Assume the system is isolated.

$m = 10.0\,g$
$c = 0.900\,J/g\cdot°C$
$t = 130.0°C$

$m = 200.0\,g$
$c = 4.184\,J/g\cdot°C$
$t = 25.0°C$

$q_w + q_m = 0$ (1st law, isolated)

(q_w: water, q_m: metal)

$\rightarrow q_w = -q_m$

$\rightarrow m_w c_w \Delta t_w = -m_m c_m \Delta t_m$

$\rightarrow m_w c_w (t_F - t_{I,w}) = -m_m c_m (t_F - t_{I,m})$

(t_F: ? , 1 unknown! , t_F: ?)

need to rearrange + solve for t_F!

$\rightarrow m_w c_w t_F - m_w c_w t_{I,w} = -m_m c_m t_F + m_m c_m t_{I,m}$

$\rightarrow m_w c_w t_F + m_m c_m t_F = m_w c_w t_{I,w} + m_m c_m t_{I,m}$

$\rightarrow t_F (m_w c_w + m_m c_m) = m_w c_w t_{I,w} + m_m c_m t_{I,m}$

$$\rightarrow t_F = \frac{m_w c_w t_{I,w} + m_m c_m t_{I,m}}{m_w c_w + m_m c_m} = 26.1\,°C$$

Q24. (a) Using the following standard heats of formation, calculate ΔH^{o}_{rxn}, in kJ/mol, for the following combustion reaction.

$$2\ CH_3OH(l) + 3\ O_2(g) \longrightarrow 4\ H_2O(g) + 2\ CO_2(g)$$

Substance	ΔH^{o}_{f} (kJ/mol)
$CH_3OH(l)$	−238.4
$H_2O(g)$	−241.8
$CO_2(g)$	−393.5

$$\Delta H^{\circ}_{rxn} = \sum n\,\Delta H^{\circ}_{f}(\text{products}) - \sum m\cdot\Delta H^{\circ}_{f}(\text{reactants})$$

$$= \left[4 \times \Delta H^{\circ}_{f}(H_2O(g)) + 2 \times \Delta H^{\circ}_{f}(CO_2(g))\right] - \left[2 \times \Delta H^{\circ}_{f}(CH_3OH(l))\right]$$

$$= -1{,}277.4\ kJ/mol$$

(b) Calculate the kilojoules of heat (released or absorbed, **underline your choice**) if 55.5 g of CH_3OH is reacted according to the above equation.

$$55.5\ g\ CH_3OH \times \frac{1\ mol\ CH_3OH}{32.04\ g\ CH_3OH} \times \frac{-1277.4\ kJ}{2\ mol\ CH_3OH} = -1{,}110\ kJ$$

So, 1,110 kJ of heat is released!

Q25. Place the correct number next to the letter of the definition or phrase that best matches.

9 A. the distance between two successive points on a wave	1. d
7 B. quantum number that describes the shape of an orbital	2. p
6 C. quantum number that describes the size and energy of an orbital	3. Ψ^2
4 D. quantum number that describes the orientation of an orbital in space	4. m_l
5 E. quantum number that has two possible values, +½ and –½	5. m_s
8 F. the height of a wave	6. n
10 G. number of waves that pass through a particular point in 1 second	7. l
2 H set of orbitals that can hold a maximum of six electrons	8. amplitude
1 I. set of orbitals that can hold a maximum of ten electrons	9. wavelength
3 J. the probability of finding an electron in a certain region of space	10. frequency

3 Point Bonus Question

What is the wavelength of an electron of mass 9.11×10^{-31} kg traveling at 15,000 m/s?

$$\lambda = \frac{h}{m \cdot u} = \frac{6.626 \times 10^{-34}\ J \cdot s}{9.11 \times 10^{-31}\ kg \times 15{,}000\ m/s} = 4.85 \times 10^{-8}\ m$$

$$= 48.5\ nm$$

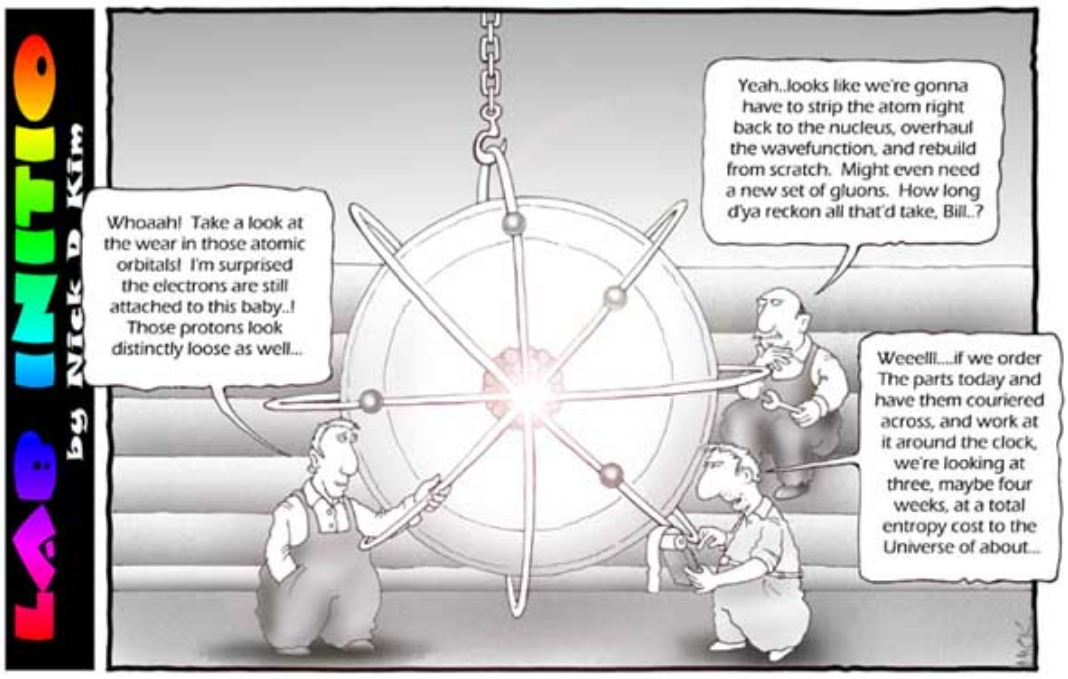
$(1\ J = 1\ kg\ m^2/s^2)$

Exam checklist:

(Check the boxes to certify the following:)

- ❒ My full name is written legibly on the front page
- ❒ My correct lab section has been indicated on the front page
- ❒ My full name is written legibly on the scantron sheet
- ❒ My exam version (A or B) is written on the scantron sheet

Thank you from the Chemistry Professors and Good Luck!



Quantum Mechanics

Useful information:

$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$q = mc\Delta t = C\Delta t$

$c = \nu\lambda$

$E = h\nu = \dfrac{hc}{\lambda}$

$c = 3.00 \times 10^{8}\ \text{m/s}$

$h = 6.626 \times 10^{-34}\ \text{J·s}$

$\lambda = \dfrac{h}{mu}$

$E_n = -R_H\left(\dfrac{1}{n^2}\right)$

$R_H = 2.18 \times 10^{-18}\ \text{J}$

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	*18*
1 **H** 1.008	*2*											*13*	*14*	*15*	*16*	*17*	2 **He** 4.003
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** 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** 74.92160	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** 101.1	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** 127.60	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba*** 137.3	71 **Lu** 175.0	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	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** [210]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra**** [226]	103 **Lr** [262]	104 **Rf** [261]	105 **Db** [262]	106 **Sg** [266]	107 **Bh** [264]	108 **Hs** [265]	109 **Mt** [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*	57 **La** 138.9	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** 162.50	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0
**	89 **Ac** [227]	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]