General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Autumn 2022

November 10, 2022

Exam # 3A

Name Key

Please print your full name, and the exam version (3A) 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, 10:10 AM – 1:00 PM)
- ❒ 2. (Wed Lab, 10:10 AM – 1:00 PM)
- ❒ 3. (Tue Lab, 11:00 AM – 1:50 PM)
- ❒ 4. (Thu Lab, 11:00 AM – 1:50 PM)

Fleeman (Sections 1 and 2)

Napper (Sections 3 and 4)

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. The distance between adjacent crests on a wave is called:

A) frequency

B) amplitude

C) wavelength

D) quanta

Q2. An endothermic reaction has:

A) a positive ΔH, absorbs heat from the surroundings, and feels cold to the touch

B) a positive ΔH, absorbs heat from the surroundings, and feels warm to the touch

C) a negative ΔH, gives off heat to the surroundings, and feels cold to the touch

D) a negative ΔH, gives off heat to the surroundings, and feels warm to the touch

Q3. Choose the reaction that illustrates ΔH°_f (standard enthalpy of formation) for $Mg(NO_2)_2$.

Need to make 1 mol from its elements in most stable form!

A) $Mg(s) + N_2(g) + 2\ O_2(g) \rightarrow Mg(NO_2)_2(s)$

B) $Mg^{2+}(aq) + 2\ NO_2^-(aq) \rightarrow Mg(NO_2)_2(aq)$

C) $Mg(s) + 2\ N(g) + 4\ O(g) \rightarrow Mg(NO_2)_2(s)$

D) $Mg(NO_2)_2(s) \rightarrow Mg(s) + N_2(g) + 4\ O_2(g)$

Q4. The value of ΔH°_{rxn} for the following reaction is −6535 kJ/mol.

$$2C_6H_6\ (l) + 15O_2\ (g) \rightarrow 12CO_2\ (g) + 6H_2O(g)$$

How many kilojoules of heat will be evolved during the combustion of 16.0 g of C_6H_6(l)?

A) 679 kJ

B) 659 kJ

C) 335 kJ

D) 669 kJ

$$\frac{16.0\text{ g } C_6H_6 \mid 1\text{ mol } C_6H_6 \mid -6535\text{ kJ}}{78.11\text{ g } C_6H_6 \mid 2\text{ mol } C_6H_6} = -669\text{ kJ}$$

→ 669 kJ released (−)

Q5. When an automobile engine starts, the metal parts immediately begin to absorb heat released during the combustion of gasoline. How much heat will be absorbed by a 165 kg iron engine block as the temperature rises from 15.7°C to 95.7°C? (The specific heat of iron is 0.489 J/g·°C.)

A) 6250 kJ

B) 6.25 kJ

C) 6.45 kJ

D) 6450 kJ

$q = mc\Delta t$

$= 165\,kg \times \frac{1000\,g}{1\,kg} \times 0.489\,\frac{J}{g\cdot°C} \times (95.7°C - 15.7°C)$ (t_f, t_I)

$= 6.45 \times 10^6\,J \times \frac{1\,kJ}{10^3\,J} = 6{,}450\,kJ$

Q6. Which of the following visible colors of light has the longest wavelength?

A) blue

B) green

C) red

D) violet

Q7. Which one of the following sets of quantum numbers is not possible? (n, l, m_l, m_s)

A) 4, 3, -2, +1/2

B) 3, 0, 1, -1/2

C) 3, 0, 0. +1/2

D) 2, 1, 1, -1/2

$n=3$ ✓ $\ell=0$ ✓ $m_\ell=1$ ✗ $m_\ell: -\ell, \ldots, 0, \ldots, +\ell$

so if $\ell=0$, $m_\ell=0$ (only!)

Q8. Given the following thermochemical equation:

$3A \longrightarrow 4B + C \qquad \Delta H = -24$ kJ/mol

determine the value of ΔH for the reaction:

$2C + 8B \longrightarrow 6A \qquad \Delta H = ??$

1) double 2) reverse

1. ×2
2. ×-1

A) +24 kJ/mol

B) -42 kJ/mol

C) +48 kJ/mol

D) -48 kJ/mol

$-24\,\frac{kJ}{mol} \times 2 \times -1 = +48\,kJ/mol$

Q9. What is the maximum number of p orbitals allowed?

A) 0

B) 1

C) 3

D) 5

$\ell = 1 \rightarrow m_\ell = -1, 0, \text{or } +1$ (3 values!)

Q10. What is the wavelength of radiation that has a frequency of 5.39×10^{14}/s?

A) 1.61×10^{23} nm

B) 1.80×10^{-3} nm

C) 618 nm

D) 556 nm

$c = \nu\lambda \rightarrow \lambda = c/\nu = \frac{3.00 \times 10^8 \text{ m/s}}{5.39 \times 10^{14} \text{ /s}}$

$= 5.57 \times 10^{-7} \text{ m} \times \frac{\text{nm}}{10^{-9} \text{ m}} = 557 \text{ nm}$

Q11. A system where neither heat nor matter can flow between the system and the surroundings is called:

A) Open

B) Sealed

C) Closed

D) Isolated

Q12. The SI derived unit for energy is the:

A) Calorie

B) Joule

C) Erg

D) Kilowatt hour

object A will undergo $\div 4$ 4x smaller temp chg than B!

$q = m \cdot c \cdot \Delta t \rightarrow \Delta t = q/mc$ (x2, x2)

Q13. If object A has twice the specific heat capacity and twice the mass of object B, then an equal amount of heat absorbed by the two objects results in what temperature change?

(Assume no phase transition occurs.)

A) Object B will increase in temperature by twice that of object A

B) Object A will increase in temperature by twice that of object B

C) Object B will increase in temperature by four times of object A

D) Object A will increase in temperature by four times of object B

E) Objects A & B will both change by the same temperature

Q14. Enthalpy is an example of a state function. This means that:

A) Changes in enthalpy depend upon the way the process is carried out

B) The value of enthalpy does not depend upon the pressure

C) The value of enthalpy is independent of temperature

D) Changes in enthalpy do not depend upon the path taken

Q15. Which substance has a standard enthalpy of formation of zero?

A) $N_2(g)$ — most stable form (allotrope) of element!

B) Cl(g)

C) C(s, diamond)

D) He(s)

Q16. The Greek letter used for the **frequency** of a wave is:

A) nu (ν)

B) lambda (λ)

C) alpha (α)

D) psi (ψ)

Q17. Which of the following transitions in a hydrogen atom would result in **emission** of the **longest wavelength** of light?

A) 3 ⟶ 2

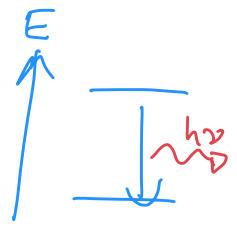
B) 3 ⟶ 1

C) 2 ⟶ 3

D) 1 ⟶ 3

$E = \frac{hc}{\lambda}$ → λ↑ means E↓

→ 3→2 is lowest ΔE, longest λ



emission!

Q18. Which quantum number primarily determines the shape of an orbital?

A) n

B) l

C) m_l

D) m_s

n = size / E

l = shape

M_l = orientation in space

M_S = e^- spin : ↑, ↓

Q19. Which quantum number primarily determines the size of an orbital?

A) n

B) l

C) m_l

D) m_s

Q20. Which quantum number primarily determines the orientation of an orbital?

A) n

B) l

C) m_l

D) m_s

□□

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. Calculate ΔH for the reaction:

$$\mathbf{5\ C(s) + 6\ H_2(g) \longrightarrow C_5H_{12}(l)}$$

(a) Use the following reactions and given ΔH values to calculate the ΔH for the reaction in **bold. Show your work clearly!**

reverse

1. $C_5H_{12}(l) + 8\ O_2(g) \longrightarrow 5\ CO_2(g) + 6\ H_2O(g)$ $\quad \Delta H = -3244.8$ kJ/mol $\times -1$

5 x 2. $C(s) + O_2(g) \longrightarrow CO_2(g)$ $\quad \Delta H = -393.5$ kJ/mol $\times 5$

3 x 3. $2\ H_2(g) + O_2(g) \longrightarrow 2\ H_2O(g)$ $\quad \Delta H = -483.5$ kJ/mol $\times 3$

(1) $5CO_2 + 6H_2O \rightarrow C_5H_{12} + 8O_2$

(2) $5C + 5O_2 \rightarrow 5CO_2$

(3) $6H_2 + 3O_2 \rightarrow 6H_2O$

⊕

-173.2 kJ/mol

(b) Specify if the reaction is endothermic or exothermic.

$5C + 6H_2 \rightarrow C_5H_{12}$ $\quad$ ΔH is negative!

Q22. Two solutions, initially at 24.69°C, are mixed in a coffee cup calorimeter. When a 200.0 mL volume of 0.100 M $AgNO_3$ solution is mixed with a 100.0 mL sample of 0.100 M NaCl solution, the temperature in the calorimeter rises to 25.16°C.

(a) Write a balanced equation for the process.

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

double repl.

$Ag^+ \; NO_3^- \quad Na^+ \; Cl^- \quad Ag^+ \; Cl^- \quad Na^+ \; NO_3^-$

(b) Determine the $\Delta H°_{rxn}$, in units of **kJ/mol**. Assume that the density and specific heat of the solutions is the same as that of water. The density of water is 1.00 g/mL and the specific heat of water = 4.184 J/g°C.

$\Delta H = \frac{q_{rxn}}{n_{rxn}}$ ① ②

#mol LR if 1:1 (LAB!!)

① $q = mc\Delta t$

$= 300.0\,g \times 4.184\,J/g{\cdot}°C \times (25.16°C - 24.69°C)$

300.0 mL, $d \approx 1\,g/mL$

$= 590.\,J$

② $AgNO_3$: $200.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.100\,mol}{L} = 0.0200\,mol\ AgNO_3$

NaCl: $100.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.100\,mol}{L} = 0.0100\,mol\ NaCl$ (LR) (*)

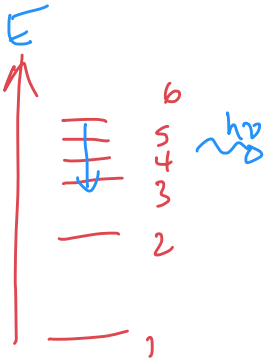
$\rightarrow \Delta H_{rxn} = 590.\,J / 0.100\,mol$

$= +5,900\,J/mol \times \frac{1\,kJ}{10^3\,J}$

$= +5.90\,kJ/mol$

$1\,kJ = 10^3\,J$

Q23. **(a)** Calculate the wavelength of light emitted or absorbed when the transition $n=6 \rightarrow n=3$ occurs.



$$E_n = \frac{-R_H}{n^2} \qquad R_H = 2.18\times10^{-18}\ J$$

$$\rightarrow \Delta E = E_3 - E_6 = -R_H\left(\frac{1}{3^2} - \frac{1}{6^2}\right)$$

$$= -1.82\times10^{-19}\ J$$

$\Delta E < 0 \rightarrow$ E is lost $\rightarrow$ light is emitted

$E_{photon} = +1.82\times10^{-19}\ J$

$E = hc/\lambda$

$$\rightarrow \lambda = hc/E = \frac{6.626\times10^{-34}\ J\cdot s \times 3.00\times10^{8}\ m/s}{1.82\times10^{-19}\ J} = 1.09\times10^{-6}\ m$$

$1.09\ \mu m$ (OR) $1090\ nm$ (OR) (IR)

(b) Determine if this transition from $n=6 \rightarrow n=3$ represents an **emission** or an **absorption**. Circle the correct choice in bold.

Q24. Fill in the blanks. For each blank, choose an answer choice from the word bank provided below. There are more answer choices than blanks.

0 1 2 3 4 Wavelength Energy Frequency Infrared Ultraviolet Gamma rays X-rays Microwave Radio waves Ground-state Excited-States Emission Absorption Principal quantum number (n) Angular momentum quantum number (*l*) Magnetic quantum number (m_l) Electron spin quantum number (m_s)

The electrons in a hydrogen atom can exist in various energy levels described using the quantum number n. The lowest energy level corresponds to a value of n = 1 and is called the ground state. Higher energy levels are referred to as excited states. When an electron transitions from (say) $n = 4$ to $n = 2$, this results in the emission of a photon of EM (electromagnetic) radiation. When comparing two sets of transitions, the one with the largest energy difference will result in the photon having a smaller wavelength.

The EM (electromagnetic) spectrum consists of various named regions. The region next to visible light with a slightly shorter wavelength is called ultraviolet, whereas the region next to visible light with a slightly longer wavelength is called infrared. In general, photons with extremely high frequency are referred to as gamma rays, whereas photons with the extremely low frequency are called radio waves.

Atoms have four different quantum numbers that are used to describe their orbitals. The one that primarily determines the energy of an orbital is the principal quantum number (n).

Q25. **(a)** Write out the chemical equation that corresponds to the standard enthalpy of formation reaction for 1-propanol, CH_3CH_2OH.

$2C(s,\text{graphite}) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3CH_2OH$

(b) A 3.22 g sample of metal absorbs 56.0 J of heat and changes temperature from 23.3 °C to 54.4 °C. Calculate the (i) heat capacity of the metal, and (ii) the specific heat capacity of the metal.

(a) $q = C \cdot \Delta t$

$\rightarrow C = \frac{q}{\Delta t} = \frac{+56.0\,J}{(54.4°C - 23.3°C)}$

$= +1.80\,J/°C$

(b) $C = mc$

$\rightarrow c = \frac{C}{m} = \frac{1.80\,J/°C}{3.22\,g}$

$= 0.559\,J/g.°C$

(c) Calculate the frequency of a photon with a wavelength of 455 nm.

$c = \nu\lambda \rightarrow \nu = c/\lambda = \frac{3.00 \times 10^8\,m/s}{455 \times 10^{-9}\,m}$

$n = 10^{-9}$

$= 6.59 \times 10^{14}\,s^{-1}$ or $1/s$ or Hz

3 Point Bonus Question

What combination of quantum numbers is referred to as a *subshell* in the quantum mechanics of an atom?

(n, ℓ)

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, B, C, or D) is written on the scantron sheet
- ❒ I have shown work for all problems (where appropriate), paying attention to
    - Significant figures / decimal places
    - Units
- ❒ I have used the conversion-factor method for all conversions
- ❒ If I have torn off the back page (periodic table), I will not turn it in with my exam!

Thank you from the Chemistry Professors and Good Luck!

Useful information:

$q = m \cdot s \cdot \Delta t$ or $q = m \cdot c \cdot \Delta t$ $q = C \cdot \Delta t$

$c = \nu \cdot \lambda$ $E = h \cdot c / \lambda$ $E = h \cdot \nu$

$c = 3.00 \times 10^{8}$ m/s $h = 6.626 \times 10^{-34}$ J·s $R_H = 2.18 \times 10^{-18}$J

$N_A = 6.022 \times 10^{23}$

$$\lambda = \frac{h}{mv} \qquad E_n = -R_H\left(\frac{1}{n^2}\right)$$

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]