## Recitation Worksheet Seven

Name: Key UGA ID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: mine is jmj81738). Do *not* enter your 81x number.
- Download this worksheet and print it if you have a printer. Write the answers in the answer boxes and show your work when appropriate. Using the instructions in the Welcome module on eLC, convert your worksheet to a PDF and then upload it to Gradescope. If you have an iPhone or Android device, you can scan and upload directly through the Gradescope app. The pages must be in the correct order or Gradescope will not be able to read it.
- If you do not have a printer, download the worksheet and type your answers in the answer boxes and upload it to Gradescope. Write your work on separate sheets of paper, convert these pages to a PDF using the instructions in the Welcome module on eLC, then upload them to the dropbox on eLC for this worksheet.
- If you are using an app to annotate the worksheet, make sure the pages are in the correct order and have the same layout as the original or Gradescope will not be able to read it.
- Answers must be written in the corresponding answer box or no credit will be awarded.
- This worksheet is due no later than **11:59 PM on the Friday of the recitation week.**
- The instructions for uploading worksheets to Gradescope can be found in the Content area of eLC in the Welcome Module.
- **You must show your work to receive credit.**

1. Consider a number of gases provided below. Which of the following will diffuse the slowest at 85 °C?

B

A. $F_2$ 38.00 g/mol
B. Xe → 131.23
C. $O_2$ 32.00
D. Ar 39.95
E. Ne 20.18

largest mass will diffuse slowest

44.01 g/mol

2. The effusion rate of carbon dioxide was measured at 70 °C. Afterwards, the effusion rate of a number of gases were collected at the same temperature. Which of the following gases provided below had the closest rate of effusion to carbon dioxide?

C

| | |
|---|---|
| A. Ar | 39.95 |
| B. Xe | 131.25 |
| C. $C_3H_8$ | 44.11 |
| D. $O_2$ | 32.00 |
| E. He | 4.00 |
| F. Ne | 20.18 |

closest in molar mass

3. An experiment was conducted in which the ratio of the rates of effusion of nitrogen gas to another diatomic gas was 2.3881. What is the identity of the unknown gas? Write the **chemical formula** in the box below.

28.02 g/mol

$Br_2$

(1) $2.3881 = \frac{\sqrt{M_2}}{\sqrt{28.02}}$

$M_2 = 159.79867$ g/mol

(2) $M = \frac{159.79867}{2}$

$= 79.899$ g/mol = Br

4. Many reactions done in the laboratory are air-sensitive and require inert gases such as $N_2$ or Ar to prevent unwanted reactivity. Although only one gas is typically chosen in any given scenario, consider a situation in which a scientist introduces 3.50 mol of $N_2$ and 3.50 mol of Ar into a closed container. If a pinhole leak is introduced at a constant temperature, which of the following statements are true after a period of time? Select all that apply.

BE

$N_2$ (28.02 g/mol) effuses faster than Ar (39.95 g/mol), so less $N_2$ will be present at a given time>0, so $P_{N2}$ will be lower.

A. The partial pressure of both gases will increase
B. The partial pressure of both gases will decrease
C. The partial pressure of both gases will remain the same
D. The partial pressure of $N_2$ will be higher than the partial pressure of Ar
E. The partial pressure of Ar will be higher than the partial pressure of $N_2$

5. Answer the following questions using the table below of five different hypothetical gases and their van der Waals correction factors

| Gas | a ($(L^2 \cdot atm)/mol^2$) | b (L/mol) |
|---|---|---|
| Gas A | 12.391 | 0.819 |
| Gas B | 13.711 | 0.901 |
| Gas C | 1.341 | 0.100 |
| Gas D | 4.981 | 0.244 |
| Gas E | 7.120 | 0.450 |

(a) Which gas will behave the most nonideally?

B

A. Gas A
B. Gas B
C. Gas C
D. Gas D
E. Gas E

B has largest correction factors

(b) Which gas would have the most similar volume to an ideal gas?

C

A. Gas A
B. Gas B
C. Gas C
D. Gas D
E. Gas E

smallest "b" correction factor

(c) Which gas would have the least similar pressure to an ideal gas?

B

A. Gas A
B. Gas B
C. Gas C
D. Gas D
E. Gas E

largest "a" correction factor

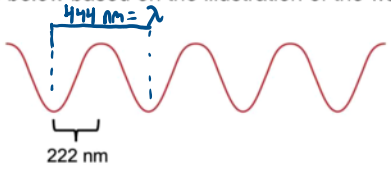
6. Consider an unknown gas that is placed in various temperature and pressure conditions provided below. Under which set of conditions will the unknown gas behave most ideally?

B

ideal under high temp. and low pressure (least intermolecular interaction, largest distance between molecules)

A. Pressure: 0.1 atm; temperature: 273 K
B. Pressure: 0.1 atm; temperature: 350 K
C. Pressure: 1 atm; temperature: 273 K (STP)
D. Pressure: 1 atm; temperature: 350 K
E. The identity of the gas is required to determine what conditions will affect ideal behavior

7. Answer the questions below based on the illustration of the wave provided:




(a) What is the wavelength of the wave (in nm)?

444 nm

(b) What is the frequency of the wave (in Hertz)?

6.76E14 Hz = $s^{-1}$

$c = \lambda\nu$

$3.00 \times 10^{8} \frac{m}{s} = \left(444 \text{ nm} \times \frac{10^{-9} \text{ m}}{\text{nm}}\right)\nu$

(c) If the wavelength of the wave is halved, what will happen to the speed of light ($c$)?

E

A. $c$ will be doubled
B. $c$ will increase, but not double
C. $c$ will be halved
D. $c$ will decrease, but not in half
E. $c$ will not change

speed of light is constant

8. Laser tattoo removal is commonly employed using lasers of various wavelengths. If the wavelength of a particular laser is 532 nm, what is its energy in Joules? What is its frequency in Hertz?

(1) $532\ nm \times \frac{m}{10^9\ nm} = 5.32 \times 10^{-7}\ m$

3.74E-19 J

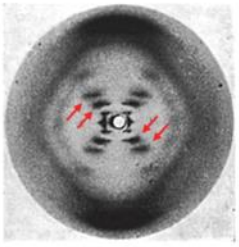
(2) $E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J \cdot s)(3.00 \times 10^8\ m/s)}{5.32 \times 10^{-7}\ m} = 3.74 \times 10^{-19}\ J$

5.64E14 Hz

(3) $C = \lambda \nu$

$3.00 \times 10^8\ \frac{m}{s} = (5.32 \times 10^{-7}\ m)(\nu)$

9. Watson and Crick were awarded the Nobel Prize in 1962 for the discovery of DNA, but it was Rosalind Franklin's research group who collected "Photo 51", an x-ray diffraction image that was critical in this discovery. The diffraction image clearly illustrated diffraction spots throughout the pattern (shown below by the red arrows) which was a result of x-rays diffracting off of the DNA structure. Based on this information, which of the following statements is/are true? Select all that apply.

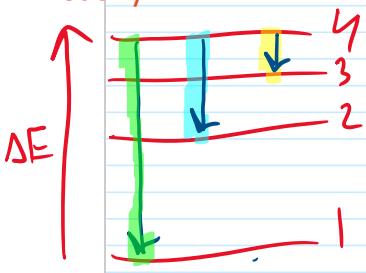


BDE

A. The spots seen were a result of destructive interference
B. The spots seen were a result of constructive interference
C. The x-rays used in this experiment had a higher wavelength than infrared or microwave radiation
D. The x-rays used in this experiment had a lower wavelength than infrared or microwave radiation
E. The x-rays used in this experiment had higher energy than infrared or microwave radiation
F. The x-rays used in this experiment had lower energy than infrared or microwave radiation

$$E = -2.178 \times 10^{-18}\ J \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

Visually:




10. Consider an electron that transitions from the n = 4 level to a lower energy level...

(a) In which transition would the resulting photon produced be at the shortest wavelength? Record the integer in the box below.

$n = 4 \rightarrow n = ?$

$n=4 \rightarrow n=3 \quad \Delta E = -1.059 \times 10^{-19}\ J$

$n=4 \rightarrow n=2 \quad \Delta E = -4.084 \times 10^{-19}\ J$

$n=4 \rightarrow n=1 \quad \Delta E = -2.042 \times 10^{-18}\ J$

$\Delta E = \frac{hc}{\lambda}$

$n =$ [ 1 ]

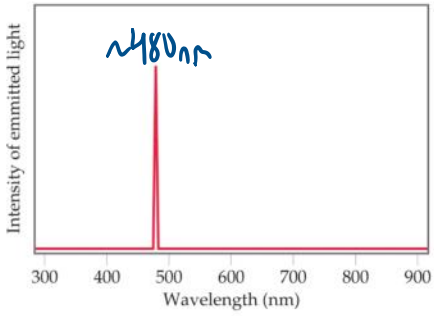
E and wavelength are inversely proportional (bigger E, shorter $\lambda$)

(b) Which transition most likely correlates to the emission of light recorded in the illustration below? Record the whole number in the box below.

$n = 4 \rightarrow n = ?$

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J \cdot s)(3.00 \times 10^{8}\ \frac{m}{s})}{480 \times 10^{-9}\ m}$$

$n =$ [ 2 ]




$= 4.14 \times 10^{-19}\ J$

closest to 4-->2
calculated above

11. Which of the following options below will have the smallest de Broglie wavelength when moving at the same velocity?

$\lambda = \frac{h}{mv}$

E

A. a chemistry book
B. a titanium atom
C. a sheet of paper
D. a drop of water
E. The planet earth
F. There is not enough information to determine this

-largest mass, smallest wavelength

12. Which statements are true based on the Bohr model of the atom? Select all that apply.

AE

A. Atomic emission spectra are due to electrons losing energy and changing energy levels
B. The energy of transition for n = 2 to n = 3 would be the same as n = 4 to n = 5
C. The first energy level is set at zero energy
D. Electrons lose energy as they travel around the nucleus
E. Each energy level has a specific energy value

13. Consider a sparkle of colored light that contains 312 kJ of energy. How many photons are in the sparkle If the wavelength of the light is 512 nm?

8.04E23 photons

$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J \cdot s)(3.00 \times 10^{8}\ \frac{m}{s})}{512 \times 10^{-9}\ m}$

$E_{photon} = 3.882421875 \times 10^{-19}\ J$

$\frac{(312\ kJ \times \frac{1000\ J}{kJ})}{3.882421875 \times 10^{-19}\ \frac{J}{photon}} = 8.036221 \times 10^{23}\ photons$

14. The binding energy of a metal is $3.99 \times 10^3$ kJ/mol. What is the minimum frequency of light (in Hertz) that is required to remove a singular electron from the metal? Hint: 1 mol = $6.022 \times 10^{23}$ electrons.

1.00E16 Hz

$$1 \text{ electron} \times \left(\frac{\text{mol}}{6.022\times10^{23}}\right) \times \left(\frac{3.99\times10^{3}\ \text{kJ}}{\text{mol}}\right) \times \left(\frac{1000\ \text{J}}{\text{kJ}}\right) = 6.625706\times10^{-18}\ \text{J}$$

$$E = h\nu$$

$$6.625706\times10^{-18}\ \text{J} = (6.626\times10^{-34}\ \text{J}\cdot\text{s})(\nu)$$

15. A student is performing a synthesis reaction that requires 457 J of energy. To provide the needed energy, these use a blue laser with a wavelength of 422 nm that produces $1.9 \times 10^{19}$ photons/sec. How many seconds do they need to run the laser?

51 seconds

$$E_{photon} = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ \text{J}\cdot\text{s})(3.00\times10^{8}\ \frac{\text{m}}{\text{s}})}{422\times10^{-9}\ \text{m}} = 4.7104265\times10^{-19}\ \text{J}$$

$$457\ \text{J} \times \frac{\text{photon}}{4.7104265\times10^{-19}\ \text{J}} \times \frac{\text{second}}{1.9\times10^{19}\ \text{photons}} = 51.0625\ \text{seconds}$$

**Extra Practice Questions: these questions will not be graded.**

1. Consider a laser that emits energy at a rate of 212 J/s. If the laser has a wavelength of 635 nm, how many photons are emitted every 2.00 seconds?

1.35E21 photons

① $2.00\ s \times \frac{212\ J}{s} = 424\ J$ total

② $E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\cdot s)(3.00\times10^{8}\ \frac{m}{s})}{635\times10^{-9}\ m} = 3.13039\times10^{-19}\ J$ per photon

③ $424\ J \times \frac{photon}{3.13039\times10^{-19}\ J} = 1.35\times10^{21}\ photons$

2. A scientist finds an unknown metal in the lab. They determine it requires approximately 342 kJ/mol of energy to remove electrons from the surface of the metal. As a result, what minimum wavelength of light is required to reproduce the photoelectric effect they observed?

350. nm

① $\frac{342\ kJ}{mol} \times \frac{mol}{6.022\times10^{23}\ photons} = 5.67918\times10^{-22}\ \frac{kJ}{photon}$

② $E = \frac{hc}{\lambda} = 5.67918\times10^{-22}\ kJ \times \frac{1000\ J}{kJ} = \frac{(6.62\times10^{-34}\ J\cdot s)(3.00\times10^{8}\ \frac{m}{s})}{\lambda}$

3. A scientific lab is performing an experiment with photons and electromagnetic radiation. They find stray photon signals that they think are coming from local radio broadcasting stations. Which radio station should they ask to turn down their signal if they are getting individual photons with a wavelength of just 304 cm?

B

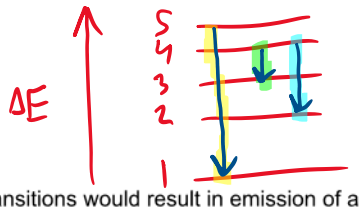
A. 106.5 MHz
B. 98.6 MHz
C. 96.1 MHz
D. 91.2 MHz

$C = \lambda\nu$

$3.00\times10^{8}\ \frac{m}{s} = (3.04\ m)\nu$

$\nu = 9.86\times10^{7}\ s^{-1} = Hz$

$9.86\times10^{7}\ Hz \times \frac{MHz}{10^{6}\ Hz} = 98.6\ MHz$




4. Which of the following electronic transitions would result in emission of a photon with the **highest** frequency?

C

A. n = 4 → n = 3
B. n = 4 → n = 2
C. n = 5 → n = 1
D. n = 1 → n = 3
E. n = 3 → n = 4

$E = h\nu$

largest E gives largest frequency

not emissions

5. What is the minimum energy (in Joules) of a photon that must be absorbed to excite the electron from the ground state in a hydrogen atom to n = 5? Report your answer to four sig figs.

2.091E-18 J

$\Delta E = -2.178 \times 10^{-18} J \left( \frac{1}{n_p^2} - \frac{1}{n_i^2} \right)$

$\Delta E = -2.178 \times 10^{-18} J \left( \frac{1}{1^2} - \frac{1}{25} \right)$

6. What is true about the Bohr model of the atom?

A

A. Electrons orbit the nucleus in fixed energy levels
B. Electrons absorb energy as photons when they fall from an excited state to a ground state
C. The spacing of energy levels is even; all transitions have the same change in energy
D. Electrons falling from an excited state can emit a range of wavelengths if they fall in between energy levels
E. Electrons have to continually absorb energy so they do not fall toward the nucleus

7. A certain atom has four bright lines in its atomic emission spectrum in the microwave, infrared, ultraviolet, and x-ray regions corresponding to n = 5 to n = 6, n = 4 to n = 2, n = 3 to n = 1, and n = 2 to n = 1. Which of these transitions corresponds to the emission in the microwave region?

A

A. n = 5 to n = 6
B. n = 4 to n = 2
C. n = 3 to n = 1
D. n = 2 to n = 1

Energy Trend:

X-ray > UV > IR > microwave

lowest energy gap must be microwave

8. Gaseous chloroethane ($CH_3CH_2Cl$) has van der Waals correction factors of a = 11.05 $L^2 \cdot atm/mol^2$ and b = 0.08651 L/mol. Gaseous carbon disulfide ($CS_2$) has van der Waals correction factors of a = 11.77 $L^2 \cdot atm/mol^2$ and b = 0.07685 L/mol. What is true about these gases? Select all that apply.

AD

A. Carbon disulfide gas experiences more attraction to itself than chloroethane
B. Chloroethane would behave the most ideally at low temperatures
C. Each mole of carbon disulfide gas takes up more volume than chloroethane
D. The higher the density of gas, the more the a factor influences the pressure
E. Carbon disulfide would behave the most ideally at high pressures

9. Four noble gases – neon, argon, krypton, and xenon - are put into identical containers. If all 4 containers are kept at the same temperature, which of the following would be true? Select all that apply.

BCE

Xe higher mass = slower
Ne lowest mass = fastest

Xe =131.29
Kr = 83.79
Ar= 39.95
Ne= 20.18

A. If a pinprick hole were put into the containers for argon and xenon, xenon would effuse 1.8 times faster than argon
B. If all four containers were opened in a room, neon would diffuse the fastest
C. If the samples of krypton and xenon were combined, then a pinprick hole were put into that container, more xenon would remain in the container after 10 minutes
D. If a pinprick hole were put into the containers for neon and krypton, krypton would effuse 4.15 times slower than neon
E. Calculating the rates of diffusion of these gases is more theoretically complicated than calculating the rates of effusion