Version D

Name: _____   **TA:** _____

SID: _____   **Section:** _____

Identification Sticker
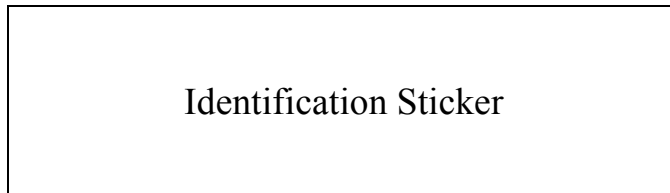
Test-taking strategy: PLEASE READ THIS FIRST!
Write your name and that of your TA on all 10 pages. This test consists of two parts:
multiple choice (**answers to be circled *and* entered on the Scantron^{TM} sheet**) and short
answer. In order to maximize your score on the exam:

- Do the questions you know how to do first.
- Then, go back and spend more time on the questions you find more challenging.
- Budget your time carefully -- don't spend too much time on one problem.
- Show all work for which you want credit and don't forget to include units.

Potentially Useful Information:

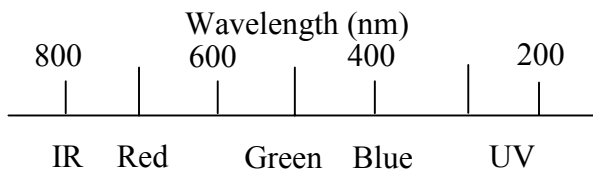$E = h\nu, \quad \lambda\nu = c$
$\lambda_{deBroglie} = h / p = h / mv$
$E_{kin}(e\text{-}) = h\nu - \Phi = h\nu - h\nu_0$
$h = 6.626 \times 10^{-34} \text{ J s}$
$c = 3.0 \times 10^8 \text{ m·s}^{-1}$
$1 \text{ nm} = 10^{-9} \text{ m}$

Color and Wavelength of Light

Wavelength (nm)

800	600	400	200

IR   Red   Green   Blue   UV

Page	Points
Multiple Choice	
7	
8	
9	
10	
Total:	

Part I Multiple Choice (4 pts each, 72 pts total) Bubble in the correct answer on your Scantron^{TM} form AND circle your answer on the exam. There is only one correct answer for each question, so you should circle and fill in one and only one answer for each question. There is no penalty for an incorrect response.

1.) The answer to question 1 is **D**. Bubble in **D** on your Scantron^{TM} form

   A) A   B) B   C) C   D) D   E) E

2.) Which of the following is an element?

   A) air   B) water   C) uranium   D) wine   E) hydroxide

3.) When 686.0 g of the lead oxide Pb_3O_4 is heated, decomposition occurs producing 16.0 g of O_2 gas and 670.0 g of a different lead oxide. What is the empirical formula of this second oxide?

   A) PbO   B) Pb_2O C) PbO_2 D) Pb_2O_3 E) $Pb_{1.5}O$

4.) Which of the following molecules has an electric dipole moment?

   A) CH_4 B) BF_3 C) XeF_2 D) ClF_3 E) CO_2

5.) How many structural isomers exist for the chlorinated hydrocarbon chlorobutane, C_4H_9Cl?

A) 2   B) 4   C) 6   D) 8   E) 10

6.) Which of the following is a valid Lewis Dot Structure for hydrazine, N_2H_2?

A) $H = N = N = H$ B) $H - \overset{..}{\underset{..}{N}} - \overset{..}{\underset{..}{N}} - H$ C) $H - \overset{.}{N} = \overset{.}{N} - H$

D) $H - N \equiv N - H$ E) $H - \overset{..}{N} = \overset{..}{N} - H$

7.) Which of the following molecules or ions is NOT linear?

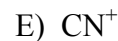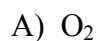A) ICl_2^- B) CO_2 C) SO_2 D) C_2H_2 E) HCN

8.) Which of the following isomers of the hydrocarbon heptane, C_7H_{16}, is chiral (the hydrogen atoms are omitted from the structures)?

A) [structure]   B) [structure]   C) [structure]   D) [structure]   E) None of the above
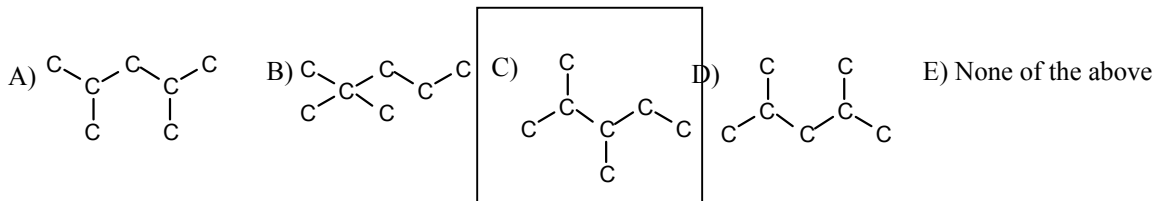
9.) Which of the following molecules or ions is isoelectronic with CN⁻?

A) O_2 B) N_2 C) NO   D) NO⁻   E) CN^+

10.) Which compound has the highest percentage of iodine by mass?

A) IF_3 B) BaI_2 C) FeI_3 D) AlI_3 E) CaI_2
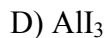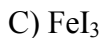
11.) Cupric sulfate solution is blue. Through a blue colored lens, what color will a cupric sulfate solution appear?

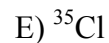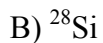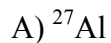A) white   B) black   C) blue   D) red   E) green

12.) Which atom has the greatest number of neutrons?

A) ^{27}Al B) ^{28}Si C) ^{32}S D) ^{32}P E) ^{35}Cl

13.)One mole of carbon atoms reacts to form C_{60}, buckminsterfullerene molecules. How many molecules of C_{60} are formed?

A) 0   B) 1   C) 1.0×10^{22} D) 6.0×10^{23} E) 3.6×10^{25}

14.)Atoms of ^{32}S traveling at 2.00×10^3 m/s have a deBroglie wavelength of 6.23×10^{-12} m. Which atoms, traveling at 2.00×10^3 m/s have a deBroglie wavelength of 1.24×10^{-11} m?

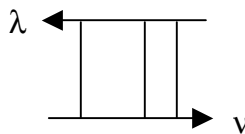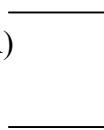A) ^{16}O B) ^{64}Cu C) ^{12}C D) ^{8}Li E) ^{48}Ti

15.)Which energy level diagram corresponds to the observed spectrum shown?
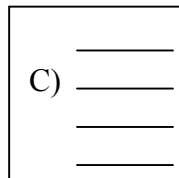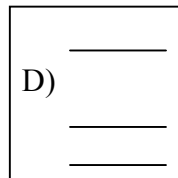

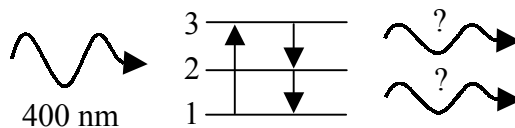A)   B)   C)   D)   E) none of the above

16.)A photon of blue light (400 nm) is absorbed and 2 photons are emitted as illustrated in the energy diagram below. To which color light do the two equivalent emitted photons correspond?

A) IR   B) Red   C) Green   D) Blue   E) UV

17.)In which of the molecules or ions below does nitrogen (N) have the highest oxidation state?
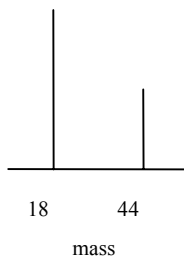
A) CN^- B) NO_2 C) NO_3^- D) NH_3 E) N_2

18.)The combustion products of a hydrocarbon with which empirical formula yield the following mass spectrum?

18   44

mass

A) C_4H B) C_2H C) CH   D) CH_2 E) CH_4

Part 2: Short Answer Problems (78 pts total)

Instructions: Enter answers in the boxes where provided. Show all work for which you wish to receive credit. <u>Where explanations are required, only the first fifteen words will be considered for your grade.</u>

1.) (39pts) Acrylonitrile is an important building block for synthetic fiber. It can be made by the reaction of propane with ammonia and oxygen, as follows:

$$2C_3H_6\text{ (g)} + 2NH_3\text{ (g)} + 3O_2\text{ (g)} \rightarrow 2C_3H_3N\text{ (l)} + 6H_2O\text{ (l)}$$
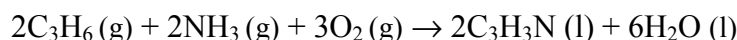
   a) (11 pts) What mass of Acrylonitrile is formed by the reaction of 1.0 mole of propane and 2.0 moles of ammonia (NH_3) in the presence of excess oxygen.
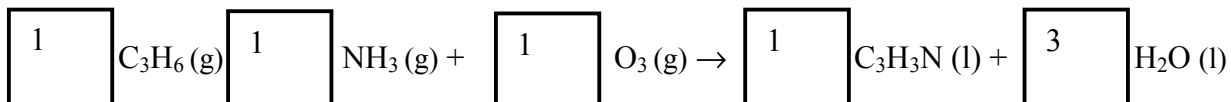
> Propane (C_3H_6) is the limiting reagent.
>
> (1 mol C_3H_6) (2 mol C_3H_3N)/(2 mol C_3H_6) = 1 mol C_3H_3N
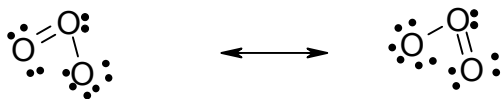>
> MW(C_3H_3N) = 53 g/mol

> Mass Acrylonitrile:
>
> 53 g

   b) (6 pts) Acrylonitrile can be formed in the presence of ozone, O_3 , rather than molecular oxygen, O_2. Balance the chemical equation for this reaction.

$\boxed{1}$ $C_3H_6\text{ (g)}$ $\boxed{1}$ $NH_3\text{ (g)} +$ $\boxed{}$ $O_3\text{ (g)} \rightarrow$ $\boxed{1}$ $C_3H_3N\text{ (l)} +$ $\boxed{3}$ $H_2O\text{ (l)}$

   c) (11 pts) Draw a valid resonance pair of Lewis Dot Structures for Ozone.

   d) (11 pts) What is the bond order of the oxygen-oxygen bond in i) oxygen (O_2) and ii) Ozone (O_3). Explain your answer.

i) oxygen (O_2)

Bond order	Explanation:
2	To obtain octets, on both "O" atoms, a double bond is needed (no resonance possible).

ii) ozone (O_3)

Bond order	Explanation:
1.5	Bond order = (total # bonds between the O atoms) / (# resonance structures)

2.) (39 pts) Sodium metal, Na has a work function equal to 4.3×10^{-19} joules.

a) (10 pts) Calculate the lowest frequency and the corresponding wavelength of light sufficient to eject a photoelectron from sodium metal?

$E_{kin} = h\nu - \Phi$

$0 = h\nu - 4.3 \times 10^{-19}$

$\nu = 6.5 \times 10^{14}$ Hz

$c = \lambda\nu$

$(3 \times 10^{8}$ m/s$)/ 6.5 \times 10^{14}$ Hz $= 460$ nm

Frequency
6.5×10^{14} Hz

Wavelength

460 nm

b) (8 pts) Will red light eject an electron from sodium metal? Circle your answer and explain.

Circle one: YES   NO   DEPENDS

Explanation:
The frequency of red light is too low to overcome the work function

c) (10 pts) How many photoelectrons are ejected from sodium metal by light of
wavelength $\lambda = 400$ nm (1 nm = 10^{-9} m) that delivers a total energy of
2.23×10^{-18} J?

$E_{photon} = hc/\lambda$

$E_{photon} = 4.97 \times 10^{-19}$ J

$E_{total} = n \times 4.97 \times 10^{-19}$ J

n = number of photons

2.23×10^{-18} J / 4.97×10^{-19} J = 4.49

# of photoelectrons

d) (11 pts) On the graph below, plot the kinetic energy of electrons ejected from
sodium metal as a function of light frequency and explain.

E_{kin}

IR   Red   Green   Blue   UV ν
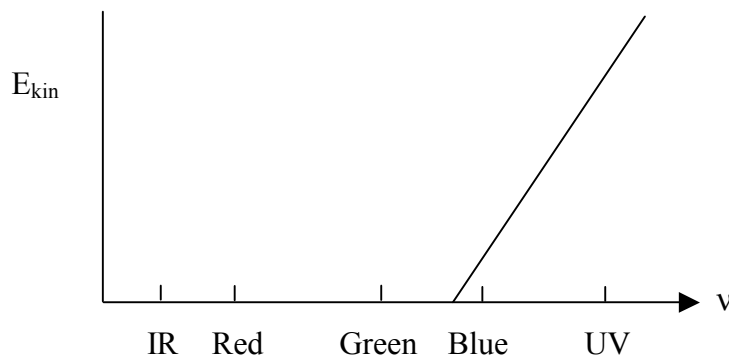
Explanation:

Linear relationship of photoelectric effect and the work function is in the
blue