UNIT 4 REVIEW (ATOMIC PHYSICS) SOLUTIONS

Concepts:

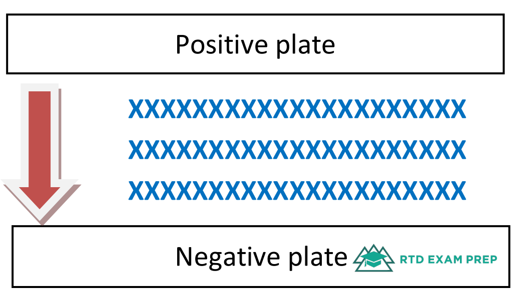
- describe matter as containing discrete positive and negative charges
- explain how the discovery of cathode rays contributed to the development of atomic models
- explain J. J. Thomson's experiment and the significance of the results for both science and technology
- explain, qualitatively, the significance of the results of Rutherford's scattering experiment, in terms of scientists' understanding of the relative size and mass of the nucleus and the atom.

Questions:

1) Match the following by drawing a line connecting all three columns correctly:

Model of the atom	Primary Physicist	Major Physics concept
"Billiard Ball" Model	Thomson	Explanation of emission spectrums
"Planetary" Model	Dalton	Elements come together in fixed ratios
"Plum Pudding" Model	Rutherford	Discovery of the electron
"Quantum" Model	Bohr	Small dense nucleus that repelled alpha particles

1) Draw a diagram to show how the velocity selector chamber of a mass spectrometer would look and explain why you drew your diagram like this:



Electric field and magnetic field have to be perpendicular in such a way to have the electric force and magnetic force cancel out.

2) If a Cd^{2+} ion was to fired at a speed of 1.78×10^{3} m/s through a velocity selector where the electric plates were 5.00cm apart and the magnetic field was 1.85T, determine the voltage that would be have to supplied to electric plate to have the Cd^{2+} ion go un-deflected.

$F_m = F_e$

$qvb = Eq$

$v = E/B$

$E = vB$

$E = 1.78 \times 10^{3}$ m/s (1.85T)

$E = 3293$ V/m

$E = V/d$

$V = Ed$

$V = 3293$ V/m (0.05m)

$V = 165$ V

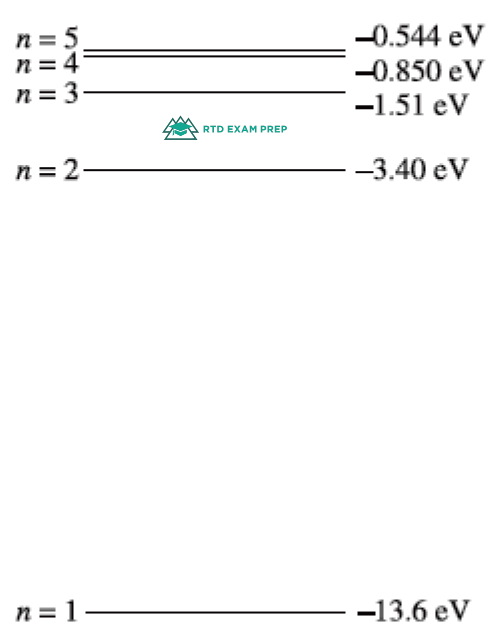
Concepts:

- explain, qualitatively, how emission of EMR by an accelerating charged particle invalidates the classical model of the atom
- describe that each element has a unique line spectrum
- explain, qualitatively, the characteristics of, and the conditions necessary to produce, continuous line-emission and line-absorption spectra
- explain, qualitatively, the concept of stationary states and how they explain the observed spectra of atoms and molecules
- calculate the energy difference between states, using the law of conservation of energy and the observed characteristics of an emitted photon

Questions:

Use the following information to answer the next two questions

Selected Energy Levels for Hydrogen



3) Determine the frequency of the emitted photon when an electron on n=5 drops to n=2.

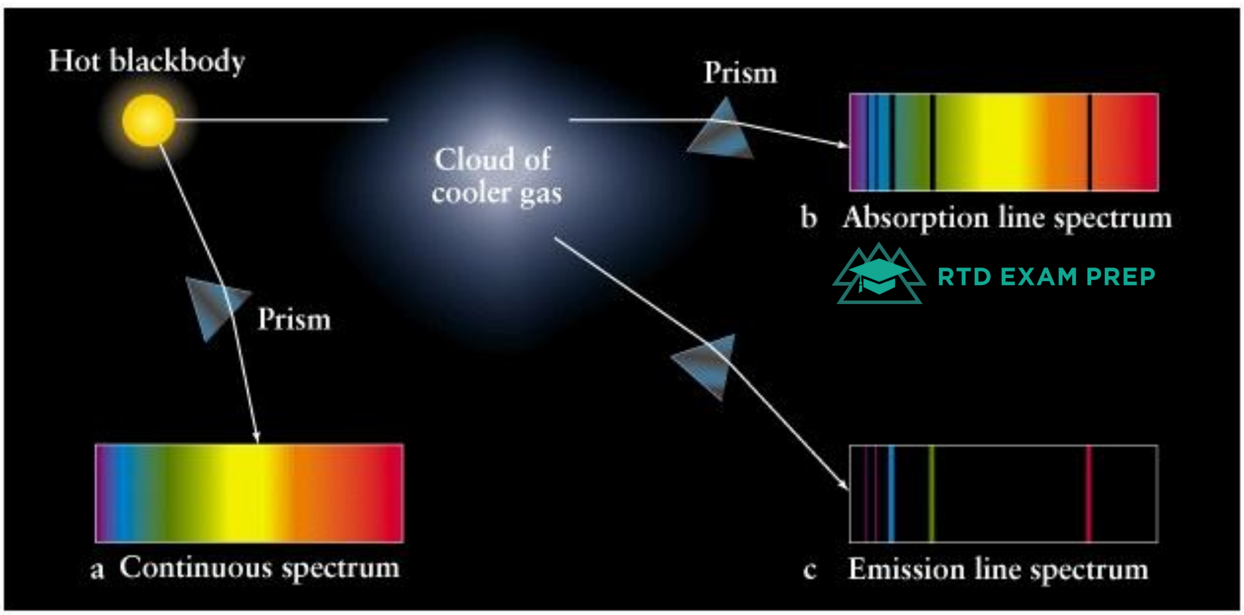
$\Delta E = E_5 - E_2$
$\Delta E = (-0.54eV)-(-1.51eV)$
$\Delta E = 0.966eV$

$\Delta E = E = hf$
$f = E/h$
$f = 0.966eV/4.14x10^{-15}$ eVs
$f = 2.33x10^{14}$ Hz

4) Determine the energy needed by a photon to have an electron jump from ground state to n=3.

$\Delta E = E_5 - E_2$
$\Delta E = (-1.51eV)-(-13.6eV)$
$\Delta E = 12.1eV$

5) Describe a situation where a continuous spectrum, emission spectrum and absorption spectrum are created respectively.



Concepts:

- explain, qualitatively, how electron diffraction provides experimental support for the de Broglie hypothesis
- describe, qualitatively, how the two-slit electron interference experiment shows that quantum systems, like photons and electrons, may be modelled as particles or waves, contrary to intuition.

Questions: RTD EXAM PREP

6) Determine the momentum of an electron travelling at $2.43 x 10^{7}$m/s. Using the momentum determine the theoretical wavelength of the electron.

p=mv
p= $9.11 x 10^{-31}$kg ($2.43 x 10^{7}$m/s)
p= $2.21 x 10^{-23}$kgm/s

P=h/ λ
λ=h/p
λ= $6.63 x 10^{-34}$Js / $2.21 x 10^{-23}$kgm/s
λ= $2.99 x 10^{-11}$ m

7) The distance between maximums when electrons from question #6 are fired through a crystal lattice with spacings of 200nm is found to be 120um apart. If the detection screen and crystal lattice are 80cm apart, determine the wavelength of the electrons.

λ=xd/nl
λ=($120 x 10^{-6}$m) ($120 x 10^{-9}$m) / (1)(0.80m)
λ= $3.00 x 10^{-11}$m

8) Using the theoretical wavelength of the electron from question #6 and the experimental wavelength from question #7, show that they verify each other.

$\lambda_{\text{experimental}}$= $3.00 x 10^{-11}$m
$\lambda_{\text{theoretical}}$= $2.99 x 10^{-11}$ m

- Because experimental and theoretical are so close it can be show that electron diffraction provides experimental support for the de Broglie hypothesis

Concepts:

- describe the nature and properties, including the biological effects, of alpha, beta and gamma radiation
- write nuclear equations, using isotope notation, for alpha, beta-negative and beta-positive decays, including the appropriate neutrino and antineutrino
- perform simple, nonlogarithmic half-life calculations
- use the law of conservation of charge and mass number to predict the particles emitted by a nucleus

Questions:

9) Label in increasing order the strength of radiation:

Gamma Radiation ___3___ Beta Radiation __2___ Alpha Radiation ___1___

10)

Determine the type of decay particle that is produced for particles A and B.

Alpha particles are produced for both A and B.

11) If 1.00g of ununquadium-289 (half life of 30.4s) is initially produced, determine the mass of ununquadium-289 remaining after 1.00 min.

$N=N_o(1/2)^n$
$N= 1.00g\ (1/2)^{1.97}$
$N=0.255g$

Number of half lives:
1.00m=60s
n= 60s/30.4s
n=1.97

Concepts:

- compare and contrast the characteristics of fission and fusion reactions
- relate, qualitatively and quantitatively, the mass defect of the nucleus to the energy released in nuclear reactions, using Einstein's concept of mass-energy equivalence.

Question:

12) Fill in the following blanks by placing fusion or fission.

a) ______fission____________ produces many highly radioactive particles.

b) _________fission__________is the splitting of a large atom into two or more smaller ones.

c) _________fusion_________ occurs in stars, such as the sun.

d) Critical mass of the substance and high-speed neutrons are required in ________fusion_______.

e) ________fission____________ is the combining of two or more lighter atoms into a larger one.

13) Determine the nuclear binding energy of uranium-235 knowing the following information:

mass of uranium-235 nucleus = 3.9021×10^{-25} kg
mass of proton = 1.6726×10^{-27} kg
mass of neutron = 1.6749×10^{-27} kg

Uranium-235 has 92 protons and 143 neutrons.

Mass defect= [(92 x 1.6726×10^{-27} kg) + (143 x 1.6749×10^{-27} kg)] - 3.9021×10^{-25} kg
Mass defect= 3.1799×10^{-27} kg

$E = m_{defect}c^2$
E= 3.1799×10^{-27} kg $(3.00 \times 10^{8}\text{m/s})^2$
E= 2.86×10^{-10} J

Concepts:

- explain how the analysis of particle tracks contributed to the discovery and identification of the characteristics of subatomic particles
- explain, qualitatively, in terms of the strong nuclear force, why high-energy particle accelerators are required to study subatomic particles
- describe the modern model of the proton and neutron as being composed of quarks
- compare and contrast the up quark, the down quark, the electron and the electron neutrino, and their antiparticles, in terms of charge and energy (mass-energy)
- describe beta-positive (β^+) and beta-negative (β^-) decay, using first-generation elementary fermions and the principle of charge conservation (Feynman diagrams are not required).

Questions:

14) Two types of pions are modelled as consisting of either a down quark and an anti-up antiquark or an up quark and an anti-down antiquark. Determine the only possible charges for these types of pions.

Up quark, u...........................	$+\frac{2}{3}e$	~5 MeV/c^2*
Anti-up antiquark, $\overline{\mathrm{u}}$.............	$-\frac{2}{3}e$	~5 MeV/c^2*
Down quark, d......................	$-\frac{1}{3}e$	~10 MeV/c^2*
Anti-down antiquark, $\overline{\mathrm{d}}$........	$+\frac{1}{3}e$	~10 MeV/c^2*

Down quark and a anti-up antiquark = (-1/3e) + (-2/3e) = -1e

Up quark and an anti-down antiquark = (+2/3e) + (+1/3e) = +1e

15) Through the use of up quarks and down quarks, show how beta positive and beta negative decay occur.

Beta positive decay:

Beta negative decay: