ZIAUDDIN UNIVERSITY
EXAMINATION BOARD

Physics
XII
Assessment

BENCHMARKS

- Ask questions that can be investigated empirically.
- Develop solutions to problems through reasoning, observation, and investigations.
- Design and conduct scientific investigations.
- Recognize and explain the limitations of measuring devices.
- Gather and synthesize information from books and other sources of information.
- Discuss topics in groups by making clear presentations, restating or summarizing what others have said, asking for clarification or elaboration, taking alternative perspectives, and defending a position.
- Justify plans or explanations on a theoretical or empirical basis.
- Describe some general limitations of scientific knowledge.
- Show how common themes of science, mathematics, and technology apply in real world contexts.
- Discuss the historical development of the key scientific concepts and principles.
- Explain the social and economical advantages and risks of new technology.
- Develop an awareness and sensitivity to the natural world.
- Describe the historical, political and social factors affecting developments in science.
- Appreciate the ways in which models, theories and laws in physics have been tested and validated
- Assess the impacts of applications of physics on society and the environment.
- Justify the appropriateness of a particular investigation plan.
- Identify ways in which accuracy and reliability could be improved in investigations.
- Use terminology and report styles appropriately and successfully to communicate information.
- Assess the validity of conclusions from gathered data and information.
- Explain events in terms of Newton’s laws and law of conservation of momentum
- Explain the effects of energy transfers and energy transformations.
- Explain mechanical, electrical and magnetic properties of solids and their significance.
- Demonstrate an understanding of the principles related to fluid dynamics and their applications.
- Explain that heat flow and work are two forms of energy transfers between systems and their significance.
- Understand wave properties, analyze wave interactions and explain the effects of those interactions.
- Demonstrate an understanding of wave model of light as e.m waves and describe how it explains diffraction patterns, interference and polarization.

CHAPTER CONTENT

	Name of chapter
Unit # 10	Thermodynamic
Unit # 11	Electrostatics
Unit # 12	Current Electricity
Unit # 13	Electromagnetism
Unit # 14	Electromagnetism Induction
Unit # 15	Alternating current
Unit # 16	Physics of solid
Unit # 17	Electronics
Unit # 18	Dawn of Modern Physics
Unit # 19	Atomic Spectra
Unit # 20	Nuclear Physics

Electromagnetism

Assessment :

PROBLEMS & EXERCISES

1. What is the direction of the magnetic force on the current in each of the six cases in Figure 5?

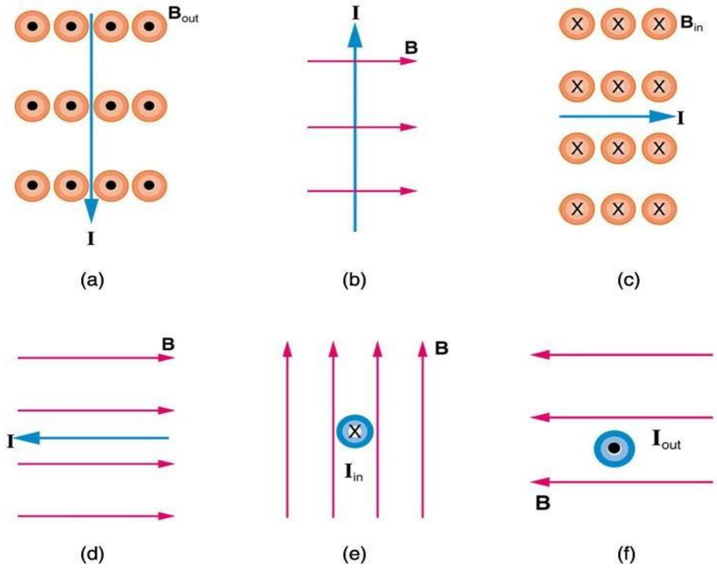


Figure 5.

2. What is the direction of a current that experiences the magnetic force shown in each of the three cases in Figure 6, assuming the current runs perpendicular to *B*?

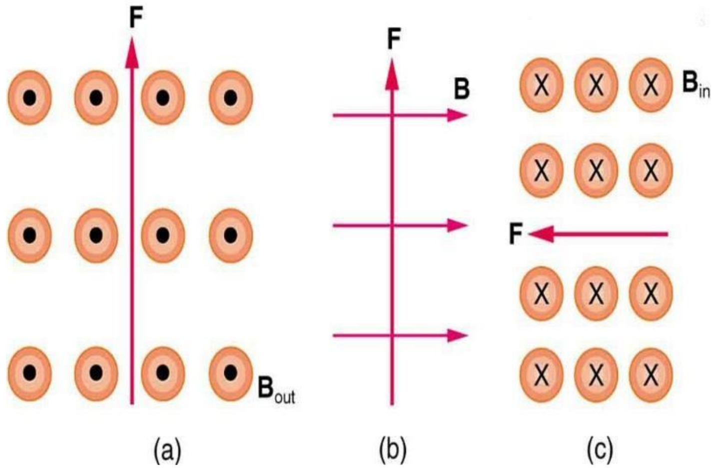


Figure 6.

CONCEPTUAL QUESTIONS

1. If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in that region is necessarily zero?

Assessment :

PROBLEMS & EXERCISES

1. What is the direction of the magnetic force on a positive charge that moves as shown in each of the six cases shown in Figure 3?

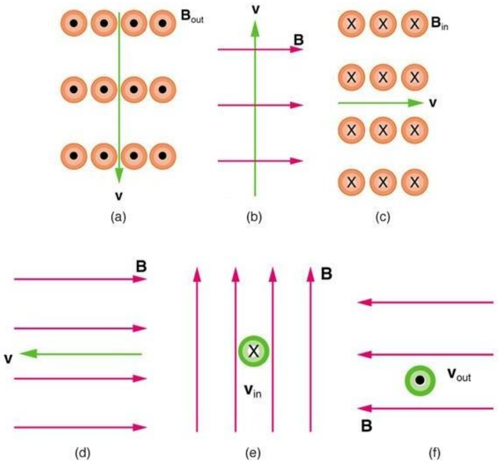


Figure 3.

. Repeat Exercise 1 for a negative charge.

3. What is the direction of the velocity of a negative charge that experiences the magnetic force shown in each of the three cases in Figure 4, assuming it moves perpendicular to **B**?

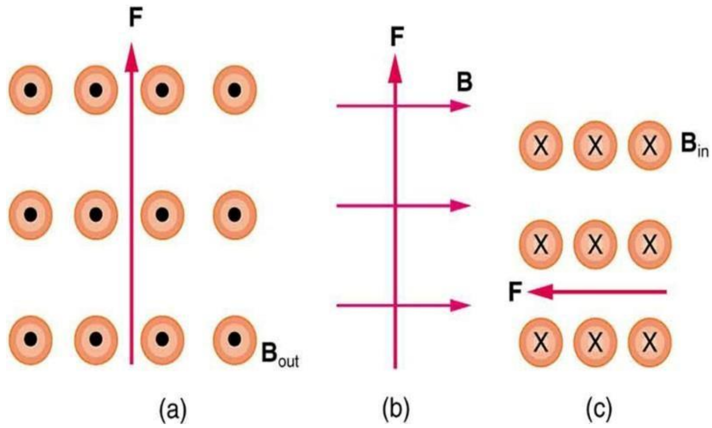


Figure 4.

4. Repeat Figure 4 for a positive charge.

5. What is the direction of the magnetic field that produces the magnetic force on a positive charge as shown in each of the three cases in the figure below, assuming **B** is perpendicular to **v**?

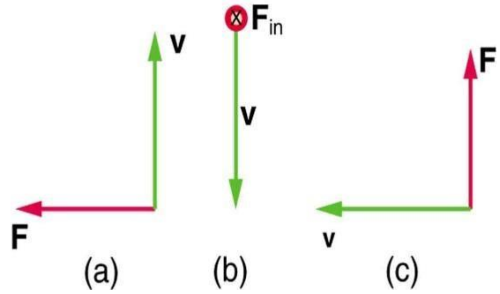


Figure 5.

6. Repeat Exercise 5 for a negative charge.

7. What is the maximum force on an aluminum rod with a 0.100-μC charge that you pass between the poles of a 1.50-T permanent magnet at a speed of 5.00 m/s? In what direction is the force?

8. (a) Aircraft sometimes acquire small static charges. Suppose a supersonic jet has a0.500-μC charge and flies due west at a speed of 660 m/s over the Earth's south magnetic pole, where the 8.00 × 10−5-T magnetic field points straight up. What are the direction and the magnitude of the magnetic force on the plane? (b) Discuss whether the value obtained in part (a) implies this is a significant or negligible effect.

9. (a) A cosmic ray proton moving toward the Earth at 5.00×10^{7} experiences a magnetic force of 1.70×10^{-16}N. What is the strength of the magnetic field if there is a 45º angle between it and the proton's velocity? (b) Is the value obtained in part (a) consistent with the known strength of the Earth's magnetic field on its surface? Discuss.

10. An electron moving at 4.00×10^{3} m/s in a 1.25-T magnetic field experiences a magnetic force of 1.40×10^{-16}N. What angle does the velocity of the electron make with the magnetic field? There are two answers.

11. (a) A physicist performing a sensitive measurement wants to limit the magnetic force on a moving charge in her equipment to less than 1.00×10^{-12} N. What is the greatest the charge can be if it moves at a maximum speed of 30.0 m/s in the Earth's field? (b) Discuss whether it would be difficult to limit the charge to less than the value found in (a) by comparing it with typical static electricity and noting that static is often absen

<u>Learning Outcomes:</u>

- explain that magnetic field is an example of a field of force produced either by current-carrying conductors or by permanent magnets.
- describe magnetic effect of current.
- describe and sketch field lines pattern due to a long straight wire.
- explain that a force might act on a current-carrying conductor placed in a magnetic field.
- Investigate the factors affecting the force on a current carrying conductor in a magnetic field. • solve problems involving the use of F = BIL sin θ.
- define magnetic flux density and its units.
- describe the concept of magnetic flux (Ø) as scalar product of magnetic field (B) and area (A) using the relation ØB = B⊥ A=B.A.
- state Ampere's law.
- apply Ampere's law to find magnetic flux density around a wire and inside a solenoid. Conceptual linkage: [2]This chapter is built on Electromagnetism Physics X 39
- describe quantitatively the path followed by a charged particle shot into a magnetic field in a direction perpendicular to the field.

• explain that a force may act on a charged particle in a uniform magnetic field.

• describe a method to measure the e/m of an electron by applying magnetic field and electric field on a beam of electrons.

• predict the turning effect on a current carrying coil in a magnetic field and use this principle to understand the construction and working of a galvanometer.

• explain how a given galvanometer can be converted into a voltmeter or ammeter of a specified range.

• describe the use of avometer / multimeter (analogue and digital).

Electromagnetism Induction

Assessment :

EXAMPLE 1. CALCULATING THE LARGE MOTIONAL EMF OF AN OBJECT IN ORBIT

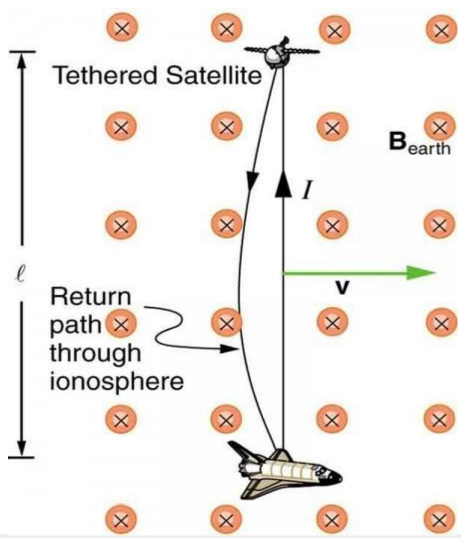


Figure 2. Motional emf as electrical power conversion for the space shuttle is the motivation for the Tethered Satellite experiment. A 5 kV emf was predicted to be induced in the 20 km long tether while moving at orbital speed in the Earth’s magnetic field. The circuit is completed by a return path through the stationary ionosphere.

Calculate the motional emf induced along a 20.0 km long conductor moving at an orbital speed of 7.80 km/s perpendicular to the Earth’s 5.00×10^{-5} T magnetic field.

Strategy
This is a straightforward application of the expression for motional emf — emf = *Bℓv*.

Solution
Entering the given values into emf = *Bℓv* gives
emf=Bℓv=(5.00×10−5 T)(2.0×104 m)(7.80×103 m/s)=7.80×103 Vemf=Bℓv=(5.00×10−5 T)(2.0×104 m)(7.80×103 m/s)=7.80×103 V.

Discussion
The value obtained is greater than the 5 kV measured voltage for the shuttle experiment, since the actual orbital motion of the tether is not perpendicular to the Earth’s field. The 7.80 kV value is the maximum emf obtained when $\theta = 90^\circ$ and $\sin \theta = 1$.

CONCEPTUAL QUESTIONS

1. Why must part of the circuit be moving relative to other parts, to have usable motional emf? Consider, for example, that the rails in Figure 1 are stationary relative to the magnetic field, while the rod moves.
2. A powerful induction cannon can be made by placing a metal cylinder inside a solenoid coil. The cylinder is forcefully expelled when solenoid current is turned on rapidly. Use Faraday's and Lenz's laws to explain how this works. Why might the cylinder get live/hot when the cannon is fired?
3. An induction stove heats a pot with a coil carrying an alternating current located beneath the pot (and without a hot surface). Can the stove surface be a conductor? Why won't a coil carrying a direct current work?
4. Explain how you could thaw out a frozen water pipe by wrapping a coil carrying an alternating current around it. Does it matter whether or not the pipe is a conductor? Explain.

PROBLEMS & EXERCISES

1. Use Faraday's law, Lenz's law, and RHR-1 to show that the magnetic force on the current in the moving rod in Figure 1 is in the opposite direction of its velocity.

2. If a current flows in the Satellite Tether shown in Figure 2, use Faraday's law, Lenz's law, and RHR-1 to show that there is a magnetic force on the tether in the direction opposite to its velocity.

3. (a) A jet airplane with a 75.0 m wingspan is flying at 280 m/s. What emf is induced between wing tips if the vertical component of the Earth's field is 3.00×10^{-5} T? (b) Is an emf of this magnitude likely to have any consequences? Explain.

4. (a) A nonferrous screwdriver is being used in a 2.00 T magnetic field. What maximum emf can be induced along its 12.0 cm length when it moves at 6.00 m/s? (b) Is it likely that this emf will have any consequences or even be noticed?

5. At what speed must the sliding rod in Figure 1 move to produce an emf of 1.00 V in a 1.50 T field, given the rod's length is 30.0 cm?

6. The 12.0 cm long rod in Figure 1 moves at 4.00 m/s. What is the strength of the magnetic field if a 95.0 V emf is induced?

7. Prove that when B, ℓ, and v are not mutually perpendicular, motional emf is given by emf = $B\ell v \sin\theta$. If v is perpendicular to B, then θ is the angle between ℓ and B. If ℓ is perpendicular to B, then θ is the angle between v and B.

8. In the August 1992 space shuttle flight, only 250 m of the conducting tether considered in Example 1 (above) could be let out. A 40.0 V motional emf was generated in the Earth's 5.00×10^{-5} T field, while moving at 7.80×10^{3} m/s. What was the angle between the shuttle's velocity and the Earth's field, assuming the conductor was perpendicular to the field?

9. Integrated Concepts Derive an expression for the current in a system like that in Figure 1, under the following conditions. The resistance between the rails is R, the rails and the moving rod are identical in cross section A and have the same resistivity ρ. The distance between the rails is l, and the rod moves at constant speed v perpendicular to the uniform field B. At time zero, the moving rod is next to the resistance R.

10. Integrated Concepts The Tethered Satellite in Figure 2 has a mass of 525 kg and is at the end of a 20.0 km long, 2.50 mm diameter cable with the tensile strength of steel. (a) How much does the cable stretch if a 100 N force is exerted to pull the satellite in? (Assume the satellite and shuttle are at the same altitude above the Earth.) (b) What is the effective force constant of the cable? (c) How much energy is stored in it when stretched by the 100 N force?

11. Integrated Concepts The Tethered Satellite discussed in this module is producing 5.00 kV, and a current of 10.0 A flows. (a) What magnetic drag force does this produce if the system is moving at 7.80 km/s? (b) How much kinetic energy is removed from the system in 1.00 h, neglecting any change in altitude or velocity during that time? (c) What is the change in velocity if the mass of the system is 100,000 kg? (d) Discuss the long term consequences (say, a week-long mission) on the space shuttle's orbit, noting what effect a decrease in velocity has and assessing the magnitude of the effect.

SELECTED SOLUTIONS TO PROBLEMS & EXERCISES

1. (a) 0.630 V (b) No, this is a very small e m f.

5. 2.22 m/s

11.(a) 10.0 N (b) 2.81×10^{8} J (c) 0.36 m/s (d) For a week-long mission (168 hours), the change in velocity will be 60 m/s, or approximately 1%. In general, a decrease in velocity would cause the orbit to start spiraling inward because the velocity would no longer be sufficient to keep the circular orbit. The long-term consequences are that the shuttle would require a little more fuel to maintain the desired speed, otherwise the orbit would spiral slightly inward.

Assessment:

For example, $I = \frac{120\text{ V}}{6\ \Omega} = 20\text{ A}$

A device drawing that much current reduces the voltage and current provided to other electrical equipment in your house, causing lights to dim.

When the motor is spinning and generating a back emf ε, the current is reduced to:

$$I = \frac{(\Delta V - \varepsilon)}{R}$$

If the back emf is ε = 108 V, we get:

$$I = \frac{(120 - 108)}{6} = \frac{12}{6} = 2\text{ A}$$

LEARNING OBJECTIVES

Describe the components and function of an RC circuit, noting especially the time-dependence of the capacitor’s charge

KEY TAKEAWAYS

Key Points

- In an RC circuit connected to a DC voltage source, the current decreases from its initial value of I_0=emf/R to zero as the voltage on the capacitor reaches the same value as the emf.
- In an RC circuit connected to a DC voltage source, voltage on the capacitor is initially zero and rises rapidly at first since the initial current is a maximum: V(t)=emf(1−et/RC)V(t)=emf(1−et/RC).
- The time constant τ for an RC circuit is defined to be RC. It's unit is in seconds and shows how quickly the circuit charges or discharges.

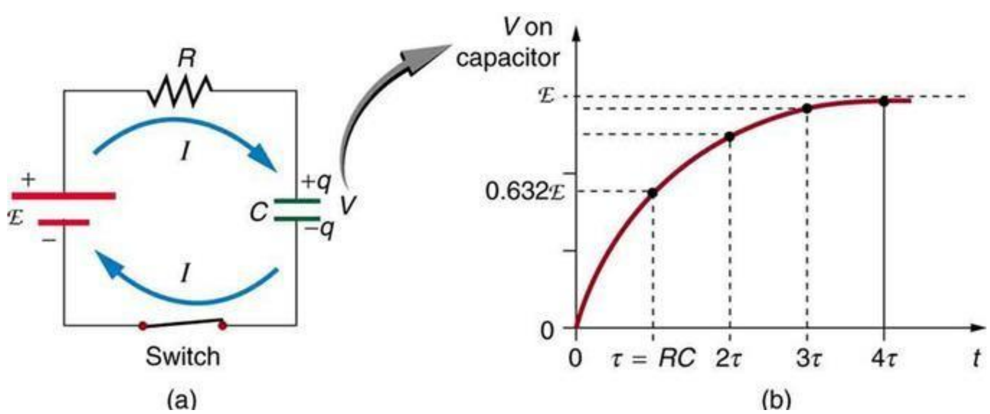
Key Terms

- **DC**: Direct current; the unidirectional flow of electric charge.
- **capacitor**: An electronic component capable of storing an electric charge, especially one consisting of two conductors separated by a dielectric.
- **differential equation**: An equation involving the derivatives of a function.

An RC circuit is one containing a resistor R and a capacitor C. The capacitor is an electrical component that houses electric charge. In this Atom, we will study how a series RC circuit behaves when connected to a DC voltage source. (In subsequent Atoms, we will study its AC behavior.)

Charging

Fig 1 shows a simple RC circuit that employs a DC voltage source. The capacitor is initially uncharged. As soon as the switch is closed, current flows to and from the initially uncharged capacitor. As charge increases on the capacitor plates, there is increasing opposition to the flow of charge by the repulsion of like charges on each plate.



Charging an RC Circuit: (a) An RC circuit with an initially uncharged capacitor. Current flows in the direction shown as soon as the switch is closed. Mutual repulsion of like charges in the capacitor progressively slows the flow as the capacitor is charged, stopping the current when the capacitor is fully charged and Q=C· emf. (b) A graph of voltage across the capacitor versus time, with the switch closing at time t=0. (Note that in the two parts of the figure, the capital script E stands for emf, q stands for the charge stored on the capacitor, and τ is the RC time constant.)

In terms of voltage, across the capacitor voltage is given by V_c=Q/C, where Q is the amount of charge stored on each plate and C is the capacitance. This voltage opposes the battery, growing from zero to the maximum emf when fully charged. Thus, the current decreases from its initial value of I_0=emf/R to zero as the voltage on the capacitor reaches the same value as the emf. When there is no current, there is no IR drop, so the voltage on the capacitor must then equal the emf of the voltage source.

Initially, voltage on the capacitor is zero and rises rapidly at first since the initial current is a maximum. Fig 1 (b) shows a graph of capacitor voltage versus time (t) starting when the switch is closed at t=0. The voltage approaches emf asymptotically since the closer it gets to emf the less current flows. The equation for voltage versus time when charging a capacitor C through a resistor R, is:

V(t)=emf(1−et/RC)V(t)=emf(1−et/RC),

where V(t) is the voltage across the capacitor and emf is equal to the emf of the DC voltage source. (The exact form can be derived by solving a linear differential equation describing the RC circuit, but this is slightly beyond the scope of this Atom.) Note that the unit of RC is second. We define the time constant τ for an RC circuit as τ=RCτ=RC. τ shows how quickly the circuit charges or discharges.

Discharging

Discharging a capacitor through a resistor proceeds in a similar fashion, as illustrates. Initially, the current is $I_0=V_0/R$, driven by the initial voltage V_0 on the capacitor. As the voltage decreases, the current and hence the rate of discharge decreases, implying another exponential formula for V. Using calculus, the voltage V on a capacitor C being discharged through a resistor R is found to be

V(t)=V0e−t/RCV(t)=V0e−t/RC.

Impedance

Impedance is the measure of the opposition that a circuit presents to the passage of a current when a voltage is applied.

LEARNING OBJECTIVES

Express the relationship between the impedance, the resistance, and the capacitance of a series RC circuit in a form of equation

Atomic Spectra

Exercise 2

Calculate de Broglie wavelength of a proton moving with a velocity of 10^4 m/s.

(Ans. 4×10^{-11} m/s)

Assessment

1. Using the Balmer equation, find the frequency of the radiation corresponding to n=3.
2. What is the frequency of the spectral line produced when an electron moves from n=5 to n=2 in a Hydrogen atom?
3. What value of n does the line at 656.3 nm in the Balmer series correspond to?
4. A photon with a wavelength of 397nm is emitted from an electron in energy level 7 of a Hydrogen atom. What is the new energy level of the electron?
5. Find the frequency in Hertz of radiation with an energy of 2.179x 10^{-18} J per photon.
6. What frequency of light would be needed to make an electron in a Hydrogen atom jump from n=1 to n=3 ?
7. A spectral line is measured to have a wavelength of 1000nm. Is this within the Balmer series?

Solutions

1.)Using the Balmer equation, find the frequency of the radiation corresponding to n=3.

The Balmer Equation is: $\nu = 3.2881 \times 10^{15} s^{-1} (1/2^2 - 1/n^2)$

We simply plug in the given value for n: $\nu = 3.2881 \times 10^{15} s^{-1} (1/2^2 - 1/3^2)$

The answer is $\nu = 4.5668\ s^{-1}$

2.) What is the frequency of the spectral line produced when an electron moves from n=5 to n=2 in a Hydrogen atom?

We use equation number 4: $E_{photon} = R_H (1/n_i^2 - 1/n_f^2)$

We simply plug in the given values for n and the Rhydberg constant for Hydrogen:

$E_{photon} = 2.179 \times 10^{-18}$ J $(1/5^2 - 1/2^2)$

$E_{photon} = 4.5759 \times 10^{-19}$ J

Next, we rearrange equation 2 to solve for frequency (v):

v=E/h

Then plug in the values for E and h:

v= (4.5759x 10^{-19} J)/(6.62607 x 10^{-34} Js)

v= 6.905x$10^{14}s^{-1}$

3.) What value of n does the line at 656.3 nm in the Balmer series correspond to?

We then substitute equation 1 into equation 2 to get this equation:

$E = hc/\lambda$

We convert the wavelength of the photon to meters, and then plug it into the equation

E=(6.62607 x 10^{-34} Js)(2.99792458 x 10^{8} ms^{1})/(6.563x10^{-7}m)

E=3.20267344 x 10^{-19}J

We then use this value to find the frequency (v).

v=(3.20267344 x 10^{-19}J) /(6.62607 x 10^{-34} Js)

v= 4.567917995 x 10^{14}

We then use equation 6 to find the energy level:

$4.567917995 \times 10^{14} = 3.2881 \times 10^{15} s^{-1} (1/2^2 - 1/n^2)$

n= 3

4.) A photon with a wavelength of 397nm is emitted from an electron in energy level 7 of a Hydrogen atom. What is the new energy level of the electron?

We use equation number 3 ($E_n = -R_H/n^2$)to find the number of joules when n=7:

$E_7 = (2.179 \times 10^{-18}\ J)/7^2$

$E_7 = -4.4469388 \times 10^{-20}\ J$

We then substitute equation 1 into equation 2 to get this equation:

$E=hc/\lambda$

We convert the wavelength of the photon to meters, and then plug it into the equation

$E_{photon} = (6.62607 \times 10^{-34}\ Js)(2.99792458 \times 10^{8}\ ms^{-1})/(3.97 \times 10^{-7} m)$

$E_{photon} = 5.00358898 \times 10^{-19}\ J$

We then subtract the energy of the photon emitted from the energy level the electron was originally in; this will give us the energy of the new energy level:

$E_{n\ final} = E_{n\ initial} - E_{photon}$

Plug the values previously calculated into the equation:

$E_{n\ final} = (-4.4469388 \times 10^{-20} J) – (5.00358898 \times 10^{-19}\ J)$

$E_{n\ final} = -5.4482829 \times 10^{-19} J$

To figure out the energy level (n), we can plug our $E_{n\ final}$ into equation number 3:

$E_n = -R_H/n^2$

$-5.4482829 \times 10^{-19} J = (-2.179 \times 10^{-18}\ J)/n^2$

We solve for n, and get:

n=2

5.) Find the frequency in Hertz of radiation with an energy of 2.179x 10^{-18} J per photon. We rearrange equation 2: v=E/h

Plug in the values:

v=(2.179 x 10^{-18} J)/(6.62607 x 10^{-34} Js)

v= 3.289 x 10^{15} s^{-1}

6.) What frequency of light would be needed to make an electron in a Hydrogen atom jump from n=1 to n=3 ?

Using equation3($E_n = -R_H/n^2$), we calculate the energy when n=1 and when n=3.

$E_1 = -2.179x10^{-18}J$

$E_3 = -2.42x10^{-19}J$

We next use equation5 to find the frequency of the photon that must be absorbed.

$\nu_{photon} = (E_i - E_f)/h$

$\nu_{photon} = [(-2.179x10^{-18}J) – (-2.42x10^{-19}J)] / (6.62607 \times 10^{-34} Js)$

$\nu_{photon}=2.923301 \times 10^{15}s^{-1}$

7.)A spectral line is measured to have a wavelength of 1000nm. Is this within the Balmer series?

No, the Balmer series does not extend into the infrared.