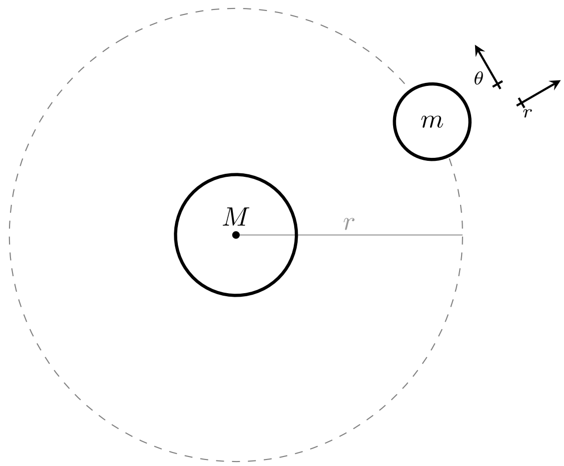
IB Physics **Name :**________________________________

Exam 1



$$F_g = \frac{mMG}{r^2}$$

Description	Symbol	Quantity
Gravitational Constant	G	$6.67 \times 10^{-11} \mathrm{N \cdot m^2/kg^2}$
Mass of Earth	m_{earth}	5.98×10^{24}kg
Mass of Moon	m_{moon}	7.36×10^{22}kg
Radius of Earth	R_{earth}	6.38×10^{6}m
Radius of Moon	R_{moon}	1.74×10^{6}m
Orbital Radius of Earth	r_{earth}	1.50×10^{11}m
Orbital Radius of Moon	r_{moon}	3.84×10^{8}m
Period of Earth's Orbit	T_{earth}	365.24 days
Period of Moon's Orbit	T_{moon}	27.3 days

Table 1: A list of physical quantities.

0.1 Definitions

Law of Universal Gravitation The law of universal gravitation states the force of gravity between two point masses is directly proportional to each mass and inversely proportional to the distance between them. This is also true for masses outside of spherically symmetric mass distributions.

$$F_g = \frac{mMG}{r^2}$$

Hookean Forces Inside a uniformly dense sphere of mass the force is Hookean, with an attractive force proportional to the displacement from equilibrium. The effective spring constant is $K = \frac{mMG}{R^3}$.

$$F_g = \frac{mMG}{R^3}r$$

Gravitational Constant The universal gravitation constant G determines the strength of the gravity force from a given mass. It may also be considered as the force that 1 kg exerts on another 1 kg mass separated by 1 meter.

$$G = 6.67 \times 10^{-11}\frac{Nm^2}{kg^2}$$

Escape Velocity Escape velocity is the initial velocity required to escape gravitational attraction. An object launched at the escape velocity will never come back (escape).

$$v_{escape} = \sqrt{\frac{2MG}{r}}$$

Kinetic Energy Kinetic energy is the energy associated with motion.

$$KE = \frac{mv^2}{2}$$

Potential Energy The potential associated with the universal gravitation force is written as follows.

$$PE = -\frac{mMG}{r}$$

Circular Orbit A circular orbit is an orbit with a constant radius r.

Elliptic Orbit An elliptic orbit is a closed orbit with changing radius r.

The first question of the exam is worth 30 points. The above table is required.

1) Consider the earth moving around the sun.

a. Determine the orbital angular velocity of the earth.

$$\omega = \frac{2\pi}{T}$$

$$\omega = \frac{2 * 3.14}{365.24 * 24 * 60 * 60}$$

$$\omega = 1.99 \times 10^{-7}\frac{\text{rad}}{\text{sec}}$$

b. Determine the speed of the earth relative to the sun.

$$V = \omega \times r$$

$$V = 1.99 \times 10^{-7} \times 1.5 \times 10^{11}$$

$$V = 3.0 \times 10^{4}\frac{\text{m}}{\text{s}}$$

c. Determine centripetal acceleration of the earth relative to the sun.

$$a = \frac{V^2}{r}$$

$$a = \frac{(3.0 \times 10^4)^2}{1.5 \times 10^{11}}$$

$$a = 6.0 \times 10^{-3}\frac{m}{s^2}$$

d. Determine the net force on the earth considering this acceleration.

$$Fnet = m \times a$$

$$Fnet = 5.98 \times 10^{24} \times 6.0 \times 10^{-3}$$

$$Fnet = 3.6 \times 10^{22} N$$

e. Determine the mass of the sun from the above.

$$\frac{mMG}{r^2} = m \times a$$

$$M = \frac{a \times r^2}{G}$$

$$M = \frac{(1.5 \times 10^{11})^2 \times 6.0 \times 10^{-3}}{6.67 \times 10^{11}}$$

$$M = 2.0 \times 10^{30} Kg$$

The second question is worth 30 points. The table is required.

2) Consider gravitation at the surface of the moon.

a. Determine the acceleration due to gravity on the surface of the moon.

$$\frac{mMG}{r^2} = m \times a$$

$$\frac{7.36 \times 10^{22} \times 6.67 \times 10^{-11}}{(1.74 \times 10^6)^2}$$

$$a = 1.62\frac{m}{s^2}$$

b. Determine the launch velocity for circular orbit.

$$\frac{mMG}{r^2} = \frac{mV^2}{r}$$

$$v = 1679.7\frac{m}{s}$$

c. Determine the launch velocity for escape from the moon's gravity.

$$Ve^2 = \frac{2MG}{r}$$

$$Ve = 2375.4\frac{m}{s}$$

d. Determine the result of launching an object at 2000 m/s into the moon's horizon.

As this object has a velocity in between the velocity for circular orbit and the escape velocity, it will have an elliptical orbit around the moon

Question three is worth 40 points.

3) Consider a capacitor. Two very large parallel conducting plates are connected to the leads of a 9 Volt battery.

a. Determine the separation between the plates to generate a 30.0 $\frac{\mathrm{N}}{\mathrm{C}}$ electric field.

$$E = \frac{V}{x}$$

$$E = \frac{9}{x}$$

$$x = 30cm$$

b. Determine the force of this electric field on a 0.012 Coulomb charge.

$$F = q \times E$$

$$F = 0.012 \times 30$$

$$F = 0.36N$$

c. Determine the change in potential energy for the 0.012 C charge moving from the 9V plate to the 0V plate.

Energy	Initial	Final
Pe	$0.018J$	0
Ke	0	$0.018J$
Te	$0.018J$	$0.018J$

Table 2: Change in energy

Answer: The change in potential energy is -0.108 J.

d. Draw the parallel plates and the electric field between them.

Answer: goes from 9V to 0V and the space between plates is of 30cm

The first question of the exam is worth 30 points.

1) Consider the following circuit

(2,0) to[battery, l=200V] (0,0); (2,0) – (2,6); (0,4) – (0,6); (0,2) to[resistor, l=100Ω] (0,4); (2,4) to[resistor, l=200Ω] (0,4); (2,6) to[resistor, l=400Ω] (0,6); (0,0) to[resistor, l=50Ω] (0,2);

a. Determine the equivalent resistance of the circuit.

Parallel:

$$\frac{1}{Req} = \frac{1}{R1} + \frac{1}{R2}$$

$$\frac{1}{Req} = \frac{1}{400} + \frac{1}{200}$$

$$Req = 133.3$$

Total circuit:

$$Req = 133.3 + 100 + 50$$

$$Req = 283\Omega$$

b. Determine the current through the 50Ω resistor.

$$V = I \times R$$

$$200 = I \times 283$$

$$I = 0.7 Amps$$

c. Determine the current through the 200Ω resistor.

$$V100 = 0.7 \times 100$$

$$V100 = 70$$

$$V50 = 0.7 \times 50$$

$$V50 = 35$$

$$V200 = Vtotal - (V100 + V50)$$

$$V200 = 200 - 105$$

$$V200 = 95$$

$$V200 = I200 \times R200$$

$$95 = I200 \times 200$$

$$I200 = 0.475 Amps$$

d. Determine the voltage drop across the 100Ω resistor.

$$V100 = I \times R100$$

$$V100 = 07 \times 100$$

$$V100 = 70V$$

e. Determine the power dissipated by the 400Ω resistor.

$$P = I \times V$$

$$P = I400 \times V$$

$$V400 = I400 \times R400$$

$$95 = I400 \times 400$$

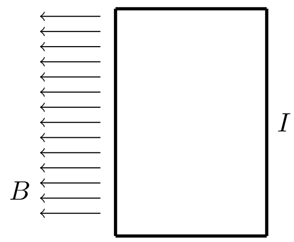
$$I400 = 0.2375 Amps$$

$$P = 0.2375 \times 95$$

$$P = 22.56 Watts$$

The second question is worth 30 points.

2) Consider a magnetic field interacting with a loop of current. The loop is a 4x6 cm rectangle. The wire contains 10^{18} free moving electrons. The magnetic field is $B = 0.050$ Tesla. The current is $I = 1.6$ Amperes.



a. Determine the direction of magnetic force on each section of the loop.

$$1 = noforce$$

$$2 = out$$

$$3 = noforce$$

$$4 = in$$

b. Determine the magnitude of force on each section of the loop.

$$Fb1 = Fb3 = zero(noforce)$$

$$Fb2 = I \times L \times B$$

$$Fb2 = 1.6 \times 6 \times 0.05$$

$$Fb2 = 0.48N$$

$$Fb4 = Fb2 = 0.48N$$

c. Describe the structure of the magnetic field created by the loop.

Inside the loop a magnetic field is created. This field is located in the middle of the loop. It is basically dots in the middle of the loop.

d. Determine the subsequent motion of the loop if it is free to move.

The loop will have a circular motion of 180 degrees until the B field inside the loop aligns with the B field outside it and consequently there are no parallel currents and then each side pushes the field in one side. As a result the loop will stop moving.

Question three is worth 30 points.

3) Consider a charged capacitor that holds 60×10^{-3} Coulombs with 12 Volts of potential. The capacitor is connected in series with a 300 Ω resistor. The capacitor begins discharging at $t = 0$.

a. Draw the circuit described above.

Well, it is a square with the resistor and the ”space” that proves it is a capacitor. In one side is the negative and the other is the positive.

b. Draw a graph of the current as a function of time, $I(t)$. Include the value of the initial current.

The Y component is I and the X component is T. It starts at the initial current and goes near zero (not a strait line).

$$V = I \times R$$

$$12 = I \times 300$$

$$I = 0.04 Amps$$

c. Explain how the capacitor functions as a battery in this system.

The charged capacitor has 12 volts of potential. Because of this a current is created in the system. Normally, what provides volts to a system is a battery; therefore, the capacitor functions as a battery in this system. Question

four is worth 10 points.

4) Two long straight wires, separated by 50 cm, run parallel and carry current in opposite directions.

Describe the magnetic force between the wires.

As the currents are in opposite directions they repel.

Explain how these wires could be used to define the Ampere.

This wires could be used to define Ampere because according to his law the length between the wires interfere in the magnetic force generated by the wires. Also, when the current is in the same direction the wires attract. The wires can define Ampere because both the B field and the I x L determine the direction of the force.

Mass Spectroscopy

1 Definition

Mass Spectrometry is an analytical technique that helps identifying the amount of electrons present in a sample by measuring the mass-to-charge ratio.

2 Physical Principles

Before understanding how the concept of mass spectrometry works, there are essential principles that need to be defined. First, in a magnetic field, also known as "B field" the force generated by the field is calculated by the formula:

$$FB = q \times v \times B$$

Analysing this formula it is possible to see that the velocity of the electron interferes in the force of the field. Also, both the direction of the velocity and the B field determine the direction of the B field. When the velocity is perpendicular to the B field the sine of the angle between both is 1. Therefore, the formula does not include the sine oh theta. Furthermore, another important principle to have knowledge is Newtons' second law. According to it, there is a formula to determine the net force. This formula is:

$$Fnet = m \times a$$

In the case of magnetic fields the net force is the magnetic force. Therefore, it is possible to imply that:

$$q \times v \times B = \frac{m \times v^2}{R}$$

Then, by cross multiplying the formula it is possible to see that:

$$\frac{m}{q} = \frac{RB}{V}$$

By analysing this formula it is possible to state that the mass-to-charge ratio is determined in order to see how many electrons are present in the field. Depending on the ratio the electrons hit the detector at different points. Each point has a signal, therefore is used to identify the molecule.

3 Sample

The image below shows how the electron interacts in a magnetic field with the detector.

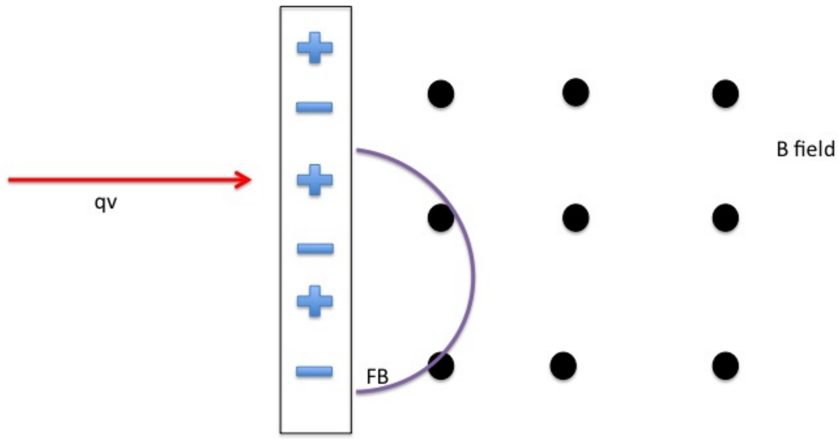


Figure 1: Mass Spectrometry Sample

4 Example: Unsaturated Ketone

In the graph below it is possible to observe that mass spectrometry helps determine a molecule.

5 Conclusion

After reading this text you, reader, is now able to understand what is mass spectrometry. Not only that, but also you know how to calculate the mass-to-charge ratio, which is the one that determines where the electron will hit the detector. Mass spectrometry is essential for determining which molecule is passing through the magnetic field. By detecting where each electron hits it is possible to determine the molecule as a whole. Now you reader have a better knowledge of this analytical technique chemicals and physicists use: mass spectrometry.

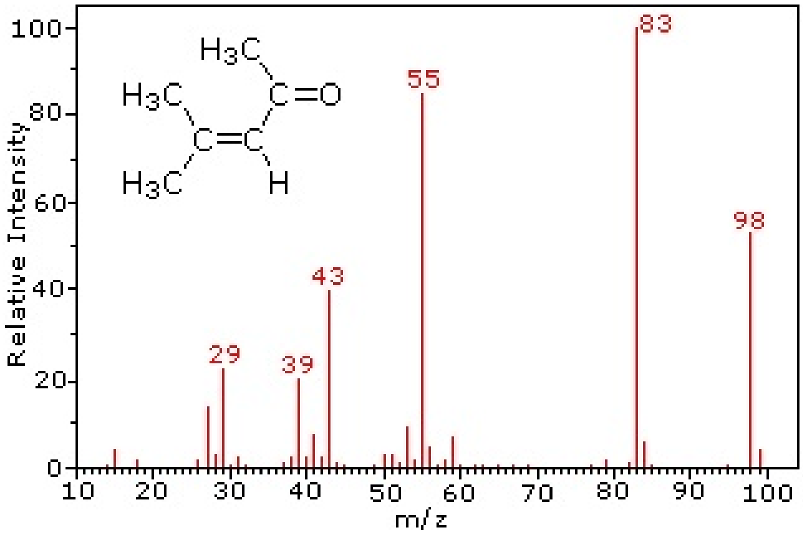


Figure 2: Unsaturated Ketone

Specific Heat Capacity of Metals

6 Definitions

Heat Heat is the measure of the internal kinetic energy of a substance.

Temperature Temperature is a measure of the kinetic energy of a particle. It is the degree or intensity of heat in a substance. Celcius is a unit of temperature. One degree Celcius represents the temperature change of one gram of water when 2.39×10^{-5}Joules of heat is added to it.

Specific Heat Capacity The specific heat capacity is the energy transferred to one kilogram of substance causing its temperature to increase by one degree Celcius.

Thermal Equilibrium Thermal equilibrium is a condition where two substances in physical contact with each other exchange no net heat energy. Substances in thermal equilibrium are at the same temperature.

7 Theory

The change in the internal energy of an object or substance is equal to the product of the mass and the specific heat capacity and the change in temperature.

$$\Delta U = mC_p\Delta T$$

When water and the metal samples are in thermal equilibrium the change in heat of the water is equal in magnitude to the change in heat of the metal.

$$\Delta U_{metal} = \Delta U_{water}$$

From this relationship we may derive a formula for the specific heat capacity of the metal sample given the mass of metal, mass of water, change in temperature of the water, change in temperature of the metal and the specific heat capacity of water.

$$m_{metal}C_{metal}\Delta T_{metal} = m_{water}C_{water}\Delta T_{water}$$

$$\boxed{C_{metal} = \frac{m_{water}}{m_{metal}}\frac{\Delta T_{water}}{\Delta T_{metal}}C_{water}}$$

Torque and Angular Momentum

Torque:

$$t = rxF$$

Angular Momentum:

$$L = rxp$$

counterclockwise direction: positive

clockwise direction: negative