ADVANCED LEVEL PHYSICS NATIONAL EXAMINATION PAPER 2020-2021 ánswers

SECTION A: Attempt all questions. (55 marks)

1) **Answer:**
   a) **False**
   b) **True**
   c) **False**
   d) **False**
2) **Answer:**
   a)

Quark	Electric charge (unit of e)	Name of the corresponding subatomic particle
Uud	+1	**Proton**
Udd	0	**Neutron**

   b) **Baryons**
3) **Answers**
   a) **Half – duplex**
   b) **Mobile phone**
   c) **Analog system**
   d) **Radio broadcasting**
4) **Answer:**
   a) **Wave-particle duality means that light and particles of matter exhibit the properties of waves or the properties of particles**
   b) **Its energy E = P.C = 8.00×10^{-21} x 3 x 10^{8}J = 2.40 x 10^{-12}J**
      Or
      E = hf = h $\frac{c}{\lambda} \Rightarrow p = \frac{h}{\lambda}$
      E = P.C
5) **Answer:**
   a) **The path difference between two waves forming a dark fringe**
      $\delta = \frac{(2n+1)\lambda}{2}$ where n = 0, 1, 2, 3, 4, …
      δ *is odd number of* $\frac{\lambda}{2}$ *or* $\delta = m\frac{\lambda}{2}$, *where* $n = 1, 3, 5$
      The phase difference $\phi = (2n+1)\pi$ *rad. where* $n = 0, 1, 2, 3, 4, ..$
      ϕ *is an odd multiple of* π *rad or* 180°
      The waves must be out of phase by half a wavelength, this means that the crest of one wave will be over the trough of the other.
   b) **Diffraction of waves**
   c) **Monochromatic waves are waves of a single frequency or single wavelength or single colour.**

6) **Answer:**

a) **Properties of cathode rays:**

- ✓ They travel linearly/ in straight line from cathode
- ✓ They have a negative electric charge/ they are formed by electrons.
- ✓ Magnetic field can deflect them
- ✓ Electric field can deflect them.
- ✓ They possess momentum and kinetic energy
- ✓ They produce fluorescence when they strike the glass wall of the discharge tube (cathode ray tube)
- ✓ They produce x-rays when they strike a metal target
- ✓ They can ionize gas through which they pass
- ✓ They affect the photographic plate
- ✓ They can penetrate through thin aluminium plate
- ✓ They cause mechanical motion of small pin wheel placed in their path
- ✓ They make phosphor glow

b) **i) Positive work**

Because F = qE, the force and the electric field are parallel and point in the same direction as the displacement.

ii) The electric potential energy decreases because the positive charge moves from the higher potential (cathode) to lower potential (anode) due to electric field.

Or

When a positive charge moves naturally in the direction of the electric field, it is moving from high electric potential energy to low electric potential energy while a negative charge moves naturally from a lower electric potential energy to a higher electric potential energy in the presence of electric field.

7) **Answer:**

a) **– Floods**
- **Landslides**
- **Lightening strike**
- **Earthquakes**
- **Epidemic diseases**
- **strong winds**
- **Soil erosion**
- **Droughts**
- **Heavy rainfall**

b) **The government must improve our flooding warning system, giving people more information about it, more time to take action before starting of rainy season like construction of house in secure zones, advance warning and pre-planning can significantly reduce the impact from flooding**

- ✓ **Tackle climate change**

  Climate change has contributed to a rise in extreme weather events which are the major causes of the floods.
- ✓ **Modify homes and business to help them withstand**

  - Use of robust materials when construction houses

- Water proofing homes and businesses must be suggested

✓ All Rwandans must construct buildings above floods level
- All buildings including houses and business must be constructed in secure zone not in the swamps or on the soft soils with a high slope which can cause landslides.

✓ Protect wetlands and introduce plant trees strategically
- The creation of more wetlands which can act as sponges, soaking up moisture and wooded areas can slow down water where rivers overflow.
- These areas must not be destroyed to give more room for agriculture. Halting deforestation and wetland drainage, reforesting upstream areas and restoring damaged wetlands could significantly the reduce the impact of climate on flooding.

✓ Improve soil conditions
Terraces and well-drained soil can absorb huge quantities of rainwater, preventing it from running into rivers thus create flood.

✓ Put up more flood banners

8) Answer:

a) Ultrasound imaging (ultrasonography) uses high frequency sound wave to view inside the body. Or Ultrasound waves are not electromagnetic waves and thus they cannot be ionizing radiation

b) i) – Magnetic resonance imaging (MRI)
- Endoscopy
- Infra-red thermography

ii) Ionizing radiation is used in:
- Radioscopy (use of x-rays)
- Mammography
- Computerized tomography (CT)
- Fluoroscopic imaging
- Radionuclide imaging (use of gamma rays)

c) The ultrasound imaging is produced based on the reflection of high frequency sound waves of the body structure. The strength (amplitude) of the sound signal and the time it takes for the wave to travel through the body provide the information necessary to produce an image.

9) Answer:

a) - Increase overall temperature of the earth's atmosphere (global warning)
- Increase wildfires
- Extreme weather events etc
- change in rainfall

b) The surface temperature of a block body is given by:

$\lambda_{max} T = b$

$T = \frac{2.9x10^{-3}mK}{475x10^{-9}m} = 6105K$

10) Answer:

a) The refractive index of the prism, $n = \frac{3x10^8}{2.4x10^8} = 1.25$

b) $1.25\sin\theta = 1\sin 90^{o}$, $n_g\sin\theta = n_a \sin 90^{o}$

$\theta = 53^{o}$

c) It is monochromatic or it contains wave of single wavelength/ colour/ frequency. The monochromatic light passing through a prism can be deviated but cannot be dispersed (split into its constituent colour) since it contains wave of single wavelength/ colour/ frequency.

11) Answer:

a) The time taken by the ball is given by:

$y = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2x19.62}{9.81}}sec = 2\,sec$

b) The horizontal distance

$\lambda = Vt = (10m/s)\,x\,(2.00sec) = 20.00m$

12) Answer:

a) - Mass of the two objects
- Distance between them
- Acceleration due to gravity
- Densities
- Volumes

b) The gravitational force on the satellite is equal to the centripetal force exerted on it

$\frac{GMm}{r^2} = \frac{mv^2}{r}$

$V = \sqrt{\frac{GM}{r}}$

Or

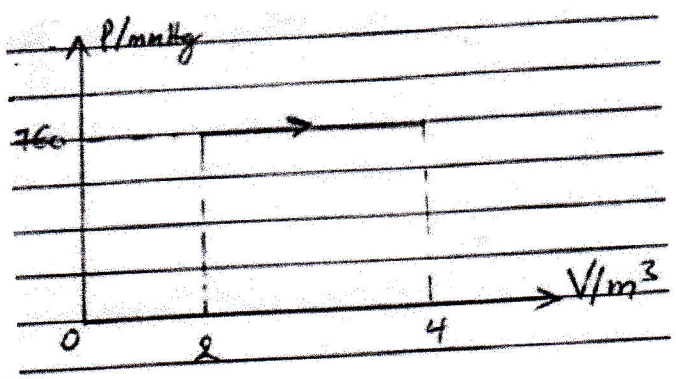
$V = \sqrt{gr}$ because $g = \frac{GM}{r^2}$

Where g is the acceleration due to gravity and G is the gravitational constant.

Note: $\frac{GMm}{r^2} = mg$

13) Answer:

a)



b) The final temperature is given by: $\frac{V}{T} = \frac{V'}{T'}$

$T' = \frac{4}{2}x\,298K = 596K$

c) The change in internal energy (DU = Q+W) of a system decreases as the gas expand. The work ($V = P\Delta V$) *is done* by the system by convention the work done by the system w is negative if $\Delta U = Q + W$

14) Answer:

a) i) $a = -w_o^2 X$ is a simple harmonic motion

ii) $a = \frac{v_o^2}{r}$ is a uniform circular motion

b) The total mechanical energy if the system;

$E = \frac{1}{2}KA^2 = \frac{1}{2}x\ 35x\ (4x10^{-2}) = 0.028J$

15) Answer:

a) Milky way galaxy

b) The light observed from distant stars and galaxies is shifted toward lower frequencies to the red end of the spectrum. This is the Doppler shift or red shift. The red-shift is evidence that the universe is expanding (moving away from a central point) and thus it supports the big bang theory. This means that they are receding with respect to the Earth.

The equation for the observed frequency of a light when the source is travelling away from you (red shift) $f_r = f\left(\frac{c}{c+v_r}\right)$ where Vr is the speed of galaxy star and fr is the frequency observed by a stationary observes on Earth. Red-shift for wavelength, $\lambda_r = \lambda\left(\frac{c-Vr}{c}\right)$

c) The speed $Vr = \left(\frac{\lambda_r-\lambda}{\lambda}\right)C$

$V_r = \left(\frac{400.2-393.4}{393.4}\right)x\ 3x10^8\ m/s = 5.2x10^6 m/s$

It is moving away from us because 400.2nm-393.4nm = 6.8nm is positive

Or the red-shift $Z = \frac{\lambda_r-\lambda}{\lambda} > 0$

SECTION B: ATTEMPT ANY THREE QUESTIONS (45 marks)

16) Answer:

a) Not sun, no energy and no life on Earth. Without the sun's heat and light, the earth would be a lifeless ball of ice coated rock. Sun warms our oceans, stirs our atmosphere, generates our weather patterns, drives water cycle and gives energy to the growing green plants that provide oxygen and food for life on earth.

b) i) Solar energy is created by nuclear fusion that takes place in the core of the sun $^2_1H + {}^2_1H \rightarrow {}^4_2H + \gamma$

Four hydrogen nuclei combine to give one helium atom. In this process, some of the mass of hydrogen atoms is converted into energy in the form of light.

ii) 1) <u>Photovoltaic technology</u>

Photovoltaic devices generate electricity directly from sunlight via solar panel/ semiconductors.

2) <u>Concentrating solar power technology</u>

It uses curved mirrors to concentrate the sun's energy onto a receiver tube in which a higher temperature heat transfer fluid (oil) absorbs the sun's energy.

The oil at 700°C passes through a heat exchange to heat water and produce steam to drive traditional steam turbines that create electricity.

3) Solar heating and cooling technology

This technology uses solar heat collector that collects the thermal energy from the sun and uses this heat to provide hot water, space heating (solar air heating), cooling pool heating for residential, commercial and industrial applications, agricultural drying, etc.

4) Greenhouse technology

Greenhouse is a glass building in which plants that need protection from cold wheather are grown using green house.

The interior of the green house exposed to sunlight becomes significantly warmer than external temperature protecting its contents in cold weather.

c) Hydroelectric energy is a source of electricity where potential energy of water is converted into motion of running water (kinetic energy) through the force of gravitation from the Earth.

Kinetic energy of water spins turbines which operate generators to produce electricity Hydropower uses water to make electricity and water constantly moves through a vast global water cycle, evaporating from lakes and oceans due to the heating energy from the sun forming clouds, precipitating as rain or snow, then flowing in streams and rivers where the dams of hydropower are constructed and flows back to oceans.

d) Agree

- ✓ Higher initial cost: initial cost of purchasing a solar system is fairly high
- ✓ Reliability or weather dependent: the efficiency of solar system drops during cloudy and rain days
- ✓ Use of a lot of space: The more electricity you want to produce, the more solar panels you will need.
- ✓ Solar energy use can be associated with pollution: We know that pollution related to solar energy is far less compared to other sources of energy but some toxic materials and hazardous products are used to manufacture solar photovoltaic systems, batteries,..
- ✓ Solar energy storage is expensive
- ✓ Inefficiency: Most efficient solar panels convert only 22% of their available energy onto power.
- ✓ Location and sunlight availability: the latitude is one of the main factors in determining the efficiency of solar power. Not all locations get the same amount of annual sunlight.

17) Answer:

a) i) The photoelectric work function is the minimum photon-energy required to liberate an electron from a metal surface.

ii) The work function = $\phi = 2.1x1.6x10^{-19}J = 3.36x10^{-19}J$

iii) It best proves that the light is made of particles photons because the photoelectric effect is bases on the idea that the electromagnetic radiation is made of a series of particles called photons. When a photon having enough energy hits an electron on a metal surface the electron can be emitted.

iv) Energy of photon, Ep = hf = $6.63x10^{-34}$x 7.23x 10^{14}J = $4.79x10^{-19}$J

v) Energy if photon is greater than the work function or $f > f_o$ or $\lambda < \lambda_o$

b) i) Einstein equation $hf = \phi + E_k$

The maximum kinetic energy of the electrons emitted:

$E_k = 4.79x10^{-19}J - 3.36x10^{-19}J = 1.43x10^{-19}J$

ii) The stopping potential is given by:

$eVs = E_k$

$V_s = \frac{1.43\,x10^{-19}J}{1.6x10^{-19}C} = 0.89V$

c) Applications:

- ✓ Solar panel
- ✓ Solar powered calculator
- ✓ Cells used in opening and closing doors automatically
- ✓ Photoelectric cells used in fire alarm system
- ✓ Photodiodes used in imaging technology

18) Answer:

a) i) The electromotive force (emf) of a cell or a battery is the energy provided by a cell or a battery per unit electric charge passing through it. Or Potential difference across the terminal of the cell when no current is flowing.

ii) Internal resistance of a cell is the resistance provided by the electrolyte and electrodes which is present within the cell or battery and it resists the current to flow when connected to a circuit.

b) i) The current through the circuit $I = \frac{\varepsilon}{R+r} = \frac{1.52}{2.55+0.45} = 0.51A$

The terminal potential difference $V = \varepsilon - Ir = 1.52 - (0.45x0.51) = 1.29v$

ii) The power, $P = I^2R = 2.55x(0.51)^2 = 0.66W$

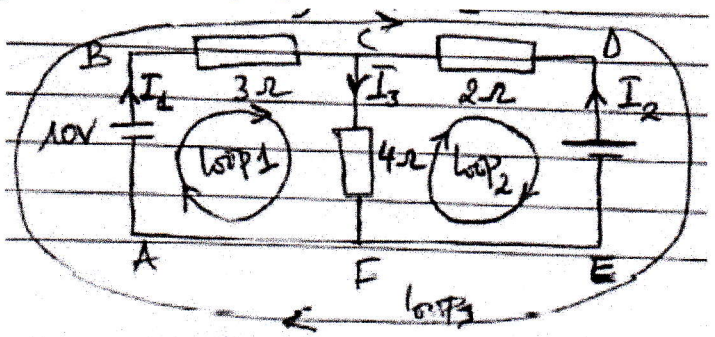
c) i) 1) Algebraic sum of all currents entering and leaving the junction/anode of an electric circuit is zero.

2) The algebraic sum of all potential differences and electromotive forces in a loop (closed path) if electrical network is zero. Or Z P.d = ZE or ZVi = 0

3) Kirchhoff's voltage law or loop rule (2nd law)

4) Kirchhoff's current law or Junction rule

ii) Junction C: $I_3 = I_1 + I_2$



Loop 1: $10 - 3I_1 - 4I_3 = 0$

$3I_1 + 4I_3 = 10$

Use of the value of I_3 from equation (1)

$3I_1 + 4(I_1 + I_2) = 10$

- The Doppler effect is used to measure the velocity of detected objects where a radar is fired at a moving target for example vehicle, radio waves are fired using a radar gun at the moving vehicle.

20) Answer:

a) i) Nuclear fission

ii) Using conservation of nucleons method:

235+ 1 = 144 + 90 + n

n=2

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{56}Ba + ^{90}_{36}Kr + 2^{1}_{0}n$

iii) When a neutron hits on uranium -235 nuclear fission occurs and this process produces two neutrons each of the released neutrons is absorbed by another uranium nucleus and causes it to split, hence releasing more or other neutrons and so on thus the chain will continue.

iv) The mass defect (loss in rest mass) for the given fission reaction

$\Delta m = mass\ of\ constituents - mass\ of\ products$

Mass of constituents :

m = (235.0439229+1.0086649) u = 236.0525948u

Mass of products:

m' = (143.9229531+ 89.9195172+2x1.0086649) u = 235.8598001u

$\Delta m = m - m' = 0.1927947u$

Energy released E = $\Delta m.c^2$ = 0.1927948C^2 x 931.5MeV/c^2 = 179.5883562MeV = 179.59MeV

b) i)

Nuclear number and proton number of nucleus produced	Nucleus formed by $\beta^-particle$	Nucleus formed by β^+particle
Nucleon number	90	64
Proton number	39	28

You can accept the following nuclear reactions because the nucleon number and the proton number are shown on atomic elements Y and X

$^{90}_{39}Sr \rightarrow ^{90}_{39}Y + ^{0}_{-1}\beta$

$^{64}_{29}Cu \rightarrow ^{64}_{28}Y + ^{0}_{+1}\beta$

ii) Any two particles for each decay process

In β^-decay, a neutron decays into a proton an electron and an antineutron

In β^+decay, a proton decays into a neutron a positron and a neutrinon

iii) Weak nuclear force/ interaction

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