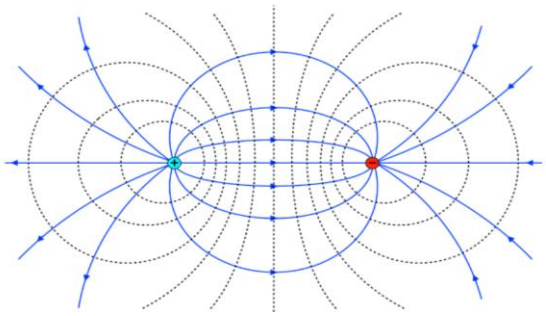
NYANZA PHYSICS EXAMINATION MARKING GUIDE, S5

1. Amplitude **1mark**

2. a) An electric dipole is a pair of electric charges of equal magnitude but opposite sign, separated by a small distance. **1mark**

b)



Equipotential lines: Dotted lines **1mark**
Electric field lines: Lines with arrows **1mark**
Two equal but opposite charges **1mark**

3. a. If an electron and a proton travel at the same speed, the proton has a shorter wavelength. **1mark** Since $\lambda = \frac{h}{mv}$ **1mark** and the mass of the proton is 1840 times greater than the mass

of the electron.

b. We say that light has particle properties since we see it act like a particle in the photoelectric effect **1mark** and Compton scattering **1mark**

4. a. B **1mark**

b. Friction force, air resistance **1mark**, dissipative force **1mark**

c. Amplitude decreases **1mark**

5. a. Let us consider the restoring forces for the two springs to be respectively;

$F_a = -k_a x$ **1mark** and $F_b = -k_b x$. **1mark** Therefore, the total restoring force is $F = F_a + F_b$

$F = -k_a x - k_b x = -(k_a + k_b)x$ *(1)* **1mark**

From Newton's second law, **F = ma** **(2) 1mark**

(1) = (2) i.e, ma= $-(k_a + k_b)x$ **1mark**

$a = \frac{-(ka + k_b)}{m}$ *(3)*

The equation (3) is in the form of $a = -w^2 x$, where $w^2 = \frac{(ka + k_b)}{m}$ *(4)*

From eq (4), $(\frac{2\pi}{T})^2 = (\frac{k_a + k_b}{m})$, $T = 2\pi\sqrt{(\frac{m}{k_a + k_b})}$ and therefore, $f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k_a + k_b}{m}}$ **1mark**

b. $k_a = k_b = k = 5.0 Nm^{-1}$ and m= 5.0g

T=$2\pi\sqrt{(\frac{m}{k_a+k_b})} = 2\pi\sqrt{\frac{m}{2k}}$. **1mark**

Therefore, T = $2\pi\sqrt{\frac{m}{2k}}$ = 2x3.14$\sqrt{\frac{5.0x10^{-3}}{2x5.0}}$

T = 0.14s **1mark**

6. i. 300kg **1mark**

ii. W= mg= 300x9.81 = **2943N** **1mark**

iii. m = $\frac{w}{g} = \frac{20}{9.81} = 2.038kg$ **1mark**

iv. g_{moon} **=** $\frac{g_{earth}}{6}$ **1mark** **=** $\frac{9.81}{6} = 1.63ms^{-1}$ **1mark**

7. a. Given:

Electric field, E=5000Vm^{-1} and mass of a neon ion, m=3.3x10^{-36}kg

$F = eE$ **1mark**

$F = 1.6x10^{-19}x5000$

$F = 8x10^{16}N$ **1mark**

b. $E=W=QV$ **1mark**

$E = 7x10^{6}x50$

E=35x10^{7}J **1mark**

8. a. 3 types of fossil fuels: Coal**1mark**, natural gas **1mark** and Oil or Petroleum**1mark**

b. i. Nuclear fission is the splitting of a heavy nucleus into two lighter nuclei of approximately the same mass accompanied by the release of energy**1mark** while Nuclear fusion is the union or combination of two very light nuclei to form a heavier nucleus which has a higher binding energy per nucleon accompanied by the release of energy. **1mark**

ii. Uses of nuclear fission

- The energy given out during nuclear fission can be changed to electricity at power stations. **1mark**
- The energy can also be used in the manufacture of atomic bombs. **1mark**

9. a. Stationary waves are formed by <u>superposition</u>**1mark** of a forward wave and the reflection wave having the same frequency, same amplitude, same speed but travelling in <u>opposite directions</u>**.1mark**

b. i. 

1mark

ii. The frequency is given by $f = \frac{v}{2l}$ **1mark**

The speed, V= 256x0.791x2=404.992ms^{-1} **1mark**

10. Comparing the given equation $\boldsymbol{x = 3.5\,sin(4t + 0.2)}$ with an alreaddy known equation

$\boldsymbol{x = Asin(wt + \varphi)}$, shows that $\omega t = 4t \Longrightarrow \omega = 4rads^{-1}$ **1mark** and A= 3.5m **1mark**

T = $\frac{2\pi}{\omega} = \frac{2\pi}{4} = 1.57$s **1mark**

$v = \pm\omega\sqrt{A^2 - x^2}$ **1mark** but with A=3.5m and x = 3.5sin(4x1.5 + 0.2) = -0.29m **1mark**

$v = \pm 4\sqrt{3.5^2 - 0.29^2}$, $v = \pm 13.95m^{-1}$ **1mark**

11. a. $hf = w_0 + \frac{1}{2}mv_{max}^2$ **1mark**

$$\boldsymbol{w_0 = hf - \frac{1}{2}mv_{max}^2 = (6.63x10^{-34})(6x10^{14}) - (2x10^{-29})}$$

$$\boldsymbol{w_0 = 3.978x10^{-19}J} \quad \textbf{1mark}$$

b. From, $\boldsymbol{w_o = hf_0}$, **1mark** $\boldsymbol{f_o = \frac{w_0}{h} = \frac{3.978x10^{-19}}{6.63x10^{-34}} = 6x10^{14}Hz}$ **1mark**

12. a. Ammeter is an instrument used to measure strong electric current **1mark** while a galvanometer is an instrument used to measure weak current. **1mark**

b. $I_3 = I_1 + I_2$ **1mark**

$14v + 10\,v = 6I_1 - 4I_2$

$24v = 6I_1 - 4I_2$

$12v = 3I_1 - 2I_2$

$\begin{cases} 12v = 3I_1 - 2I_2 & x\,1 \\ 5v = 4I_1 - I_2 & x\,2 \end{cases}$ **0.5mark** **0.5mark**

$12v + 10v = 3I_1 + 8I_1$

$22v = 11I_1$

$\mathbf{I_1 = \frac{22v}{11\Omega} = 2A}$ **1mark**

$5v = 4 \times 2 - I_2$

$5v - 8 = -I_2$

$\mathbf{I_2 = -3A}$ **1mark**

$10v = 6I_1 + 2I_3$

$10v = 6I_1 + 2(I_1 + I_2)$

$10v = 8I_1 + 2I_2$

$5v = 4I_1 + I_2$

$I_3 = I_1 + I_2$

$I_3 = 2A - 3A$

$\mathbf{I_3 = -1A}$ **1mark**

13. a. When the pendulum's length is doubled, its period becomes $\sqrt{2}$ times the initial period. **1mark**

b. Changing the <u>mass has no effect on the time period</u> of a simple pendulum. Because the period of simple pendulum does not depends on mass. **1mark**

14. a. Mathematical statement of black body radiation laws

Wien's displacement law: $\boldsymbol{\lambda_m T = Constant}$ **1mark**

$$Or\ \lambda_m T = 2.9x10^{-3}mK$$

Stefan-Boltzmann's law: $\boldsymbol{P = e\sigma AT^4}$ **1mark** where P is the power, e is the emissivity, σ is Stefan-Boltzmann's constant, A is area and T is absolute or Kelvin temperature.

b. Assuming the mercury is spherical,

Area, $4\pi r^2 = 4\pi(2.5x10^6)^2 = \mathbf{7.85x10^{13}m^2}$ **1mark**

Average temperature $T = \frac{673+73}{2} = 373\ K$ **1mark**

By Stefan-Boltzmann's law, $P = e\sigma AT^4$ **1mark** (e=1, since we assumed black body)

$\boldsymbol{P = \left(5.67x10^{-8}\right)\left(7.85x10^{13}\right)x373^4 = 8.62x10^{16}\,w}$ **1mark**

15. $\boldsymbol{y = a\sin\left[2\pi\left(\frac{t}{0.1} - \frac{x}{0.2}\right)\right]}$

a. Period, T = 0.1s **1mark**

b. Wavelength: λ = 2.0m, $v = \frac{\lambda}{T}$ **1mark** $= \frac{2}{0.1} = 20ms^{-1}$ **1mark**

c. The wavelength is travelling from left to right. **1mark**

SECTION B. Attempt <u>only three</u> questions 30Marks

16. a. i. Thermionic emission is the process by which an electron is liberated from the surface of heated metal. **1mark**

ii. Cathode rays are the streams of electrons moving at high speed in a tube highly evacuated. **1mark**

b. i. 4 main properties of cathode rays **2marks (0.5 each x4=2marks)**

- ✓ They travel from the cathode in straight lines.
- ✓ They carry a negative charge as they are electrons in nature.
- ✓ They are deflected by electric and magnetic fields
- ✓ They cause certain substances to fluoresce (glow) e.g. zinc sulphide salt.
- ✓ They produce X –rays if they are rapidly stopped by heavy metals when they have sufficiently high energy.
- ✓ They possesses kinetic energy which is converted to heat and light when they are brought to rest. They have momentum and therefore have mass.

ii. Electron gun is the source of cathode rays: **1mark**
It is composed by the Heater, grid, cathode and anode
Deflecting system: can deflects cathode rays horizontally and vertically **1mark**
Fluorescent screen: Emits light when struck by fast moving particle

c. $eV = \frac{1}{2}mv^2$

where V is accelerating p.d, v is final acquired velocity, m is mass of electron and e is the electron charge.

$v = \sqrt{\frac{2eV}{m}} = 3.2x10^6ms^{-1}$ **1mark (0.5formula+ 0.5final answer)**

time between plates $t = \frac{l}{v} = \frac{0.1}{\sqrt{\frac{2eV}{m}}}$

for the y-direction, $eE = ma \implies a = \frac{eE}{m}$ **1mark**

The deflection $y = \frac{at^2}{2}$ **1mark**

$y = \frac{eEt^2}{2m} = \frac{eE}{2m}(\frac{0.1}{\sqrt{\frac{2eV}{m}}})^2 = \frac{E}{2m}x\frac{0.01}{2V}$

$y = \frac{1}{4}x\frac{0.01E}{V} = \frac{1}{4}x\frac{0.01}{3000}x\frac{1000}{0.05} = \frac{1}{60}$

$y = 0.017m$ **1mark**

17. a. i. The force of the attraction between two given particles is inversely proportional to the square of their distance apart and directly prportional to the product of their masses**. 0.5mark**
It called universal law because it is applied to all objects in the Universe**. 0.5mark**

ii. The region of space surrounding a body that has the property of mass in which any other
body that has a mass will experience a force of attraction**. 1mark**

iii. $F = \frac{GMm}{R^2} = E_g m$**1mark** law of gravitation where $E_g = \frac{GM}{R^2}$ **1mark** is the gravitational field strength.

b. The gravitational potential at a point due to the gravitational field is defined as numerically
equal to the work done in taking a unit mass from infinity to that point.

$V = -\frac{GM}{R}$**1mark** $= -\frac{6.672x10^{-11}x6.0x10^{24}}{6.4x10^6} = -\frac{62.55MJ}{kg} = -\frac{6.255x10^7J}{kg}$**1mark**

c. The period of satellite is equal to the period of the earth as it turns about its axis, the satellite will stay over the same place on the earth while the earth rotates. On the satellite in parking orbit, $F_G = F_C \Leftrightarrow \frac{GMm}{R^2} = \frac{mv^2}{R}$ **1mark** $\Leftrightarrow v = \sqrt{\frac{GM}{R}}$ (1) **1mark**

The period: $T = \frac{2\pi R}{v} \Leftrightarrow v = \frac{2\pi R}{T}$ (2) **1mark**

Comparing (1) and (2); we get $R = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$**1mark**

18. a. Einstein's photoelectric equation: Energy of photon =Energy needed to remove an electron from the metal surface (work function) + Maximum kinetic energy of emitted electron**. 0.5mark**

Or $hf = \omega_o + \frac{1}{2}mv^2$**0.5mark**

b. i. Photovoltaic cell **1mark**

ii. In solar cell panels **0.5mark**, in calculators **0.5mark** and for powering electronic watches

c. i. The minimum potential applied between electrodes to reduce the photocurrent in the circuit to zero. It is the minimum value of the potential difference necessary to stop the electron flow**. 1mark**

ii. As $eV_s = \frac{1}{2}mv^2$**0.5mark**, $hf = \omega_o + eV_s$ **0.5mark**

So, $eV_s = hf - \omega_o \; and \; V_s = \frac{hf}{e} - \frac{w_o}{e}$ **1mark**

d. i. Laws of photoelectric emission: **1mark (at least 2 laws, 0.5mark for each)**

- ✓ Every metal surface has a minimum frequency of the incident radiation (called ***threshold frequency***) below which no photoelectric emission occurs.
- ✓ Photo electrons are emitted with a range of kinetic energies, from zero up to maximum and if the frequency of the incident radiation is increased, the maximum kinetic energy of the photoelectrons also increases.
- ✓ For a given frequency of the incident radiation, the maximum kinetic energy of the photo electrons is independent of the intensity of the radiation.
- ✓ The number of photo electrons emitted per second is proportional to the intensity of the incident radiation provided its frequency is above the threshold value
- ✓ There is no time lag between illumination and emission of electrons from a metal surface. In other words if photoemission occurs, it does so simultaneously.

Factors affecting photoelectric emission: **1mark (at least 2 factors, 0.5mark for each)**

- Intensity of incident light
- Frequency of incident light
- The type/natureof metal being used

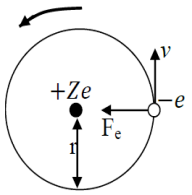
ii. $hf = \omega_o + \frac{1}{2}mv^2$ and $eV_s = \frac{1}{2}mv^2$ **0.5mark**

Thus $hf = \omega_o + eV_s$ where V_s is stopping potential.

$\boldsymbol{w_o = \frac{hc}{\lambda} - eV_s}$ **0.5mark** $= \frac{6.63x10^{-34}x3x10^{8}}{2.5x10^{-7}} - 1.6x10^{-19}x0.25$

$w_o = 7.556x10^{-19}J$ **1mark**

19. a. **2marks**



b. Electric force is given by: $F_e = \frac{e^2}{4\pi\varepsilon_o r^2}$ **0.5mark**

The centripetal force is given by: $F_c = \frac{mv^2}{r}$ **0.5mark** $or \; F_e = F_c \Leftrightarrow \frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{mv^2}{r}$

$$\Leftrightarrow \frac{e^2}{4\pi\varepsilon_0 r} = mv^2$$

$$v^2 = \frac{e^2}{4\pi\varepsilon_0 rm} \quad (1) \quad \textbf{1mark}$$

By Bohr's postulate regarding the angular momentum, $v^2 = \frac{n^2h^2}{4\pi^2r^2m^2}$ (2)

Equating (1) and (2), we get; $\frac{e^2}{4\pi\varepsilon_0 rm} = \frac{n^2h^2}{4\pi^2r^2m^2} \Leftrightarrow r_n = \frac{\varepsilon_0 n^2h^2}{\pi me^2}$ **1mark**

c. The period, $T = \frac{2\pi r_n}{v_n} = \frac{2\pi\varepsilon_o n^2h^2}{\pi me^2} x \frac{e^2}{2\varepsilon_o nh} = \left(\frac{4\varepsilon_0^2h^3}{me^4}\right)n^3$

For n =1 we get, $T_1 = \frac{4\varepsilon_0^2h^3}{me^4}\ 1 = 1.531x10^{-6}s$ **1mark**

For n =2 we get, $T_2 = 2^3T_1 = 12.24x10^{-6}s$ **1mark**

For n =3 we get, $T_3 = 3^3T_1 = 41.3x10^{-6}s$**1mark**

d. i. For the second excited state (n = 3): $E_n = \frac{E_1}{n^2} = \frac{-10.4eV}{3^2} = -1.16eV$**1mark**

ii. The ionization potential is given by the relation:

$\Delta E = E_O - E_1 = 0 - (-10.4eV) = 10.4eV$ **1mark**

20. Introduction 1mark
Development (consider 4 ideas: 4 x 2marks each = 8marks
Conclusion 1 mark

Example

The production of nuclear power presents a range of challenges and concerns, spanning from safety and security to environmental and economic issues. Here, I'll discuss these problems in detail:

1. **Safety Concerns:**
   - **Accidents:** The potential for catastrophic accidents, such as Chernobyl (1986) and Fukushima (2011), raises significant safety concerns. These incidents demonstrate the devastating consequences of nuclear accidents, including immediate fatalities, long-term health effects, and environmental contamination.
   - **Radioactive Waste:** Nuclear power plants produce radioactive waste that remains hazardous for thousands of years. The safe disposal and management of this waste pose significant technical, logistical, and societal challenges.
2. **Security Risks:**
   - **Proliferation of nuclear weapons**: The spread of nuclear technology increases the risk of nuclear weapons proliferation. Materials and knowledge used in civilian nuclear programs could potentially be diverted for military purposes.
   - **Terrorism:** Nuclear facilities are potential targets for terrorist attacks. A successful attack could lead to widespread radiation release, loss of life, and destabilization of regions.
3. **Environmental Impact:**
   - **Radioactive Pollution**: Accidents, leaks, or improper disposal of nuclear waste can lead to radioactive contamination of air, water, and soil, harming ecosystems and human health.

- **Mining and Processing**: The extraction and processing of uranium, the primary fuel for nuclear reactors, have environmental impacts, including habitat destruction, water pollution, and greenhouse gas emissions.
- **Carbon Emissions**: While nuclear power plants themselves produce minimal greenhouse gas emissions during operation, the entire nuclear fuel cycle, including mining, processing, and waste management, contributes to carbon emissions.

4. **Resource Constraints:**
    - **Uranium Depletion/scarcity:** Uranium, the fuel used in most nuclear reactors, is a finite resource. As demand for nuclear power increases, concerns arise about the depletion of uranium reserves and the geopolitical implications of relying on limited fuel sources.
    - **Energy Intensity**: The construction and operation of nuclear power plants require significant energy inputs, including mining, processing, and transporting uranium, as well as constructing and decommissioning reactors.
5. **Economic Challenges:**
    - **High Initial Costs:** The construction of nuclear power plants requires substantial upfront capital investment and long lead times. Delays and cost overruns are common in nuclear projects, making them economically risky.
    - **Subsidies and Liability:** Government subsidies and liability protections for the nuclear industry can distort energy markets and shift financial risks onto taxpayers rather than nuclear operators.
6. **Public Perception and Acceptance:**
    - **Public Opposition:** Nuclear power faces opposition from environmental groups, local communities, and the general public due to concerns about safety, waste management, and nuclear proliferation. Public resistance can hinder the expansion of nuclear energy and influence policy decisions.

Addressing these challenges requires a comprehensive approach that prioritizes safety, security, environmental stewardship, and technological innovation. This might include improved reactor designs, stricter safety regulations, better waste management solutions, increased transparency, and public engagement to build trust and acceptance. Additionally, diversifying energy sources and investing in renewable energy and energy efficiency can help reduce reliance on nuclear power and mitigate its associated risks.

END!