THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

031/1 **PHYSICS 1**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2024**

Instructions

1. This paper consists of ELEVEN questions.

2. Answer all questions in section A and B and two questions from section C.

1. (i) What does the following warning sign mean in relation to the contents in the container?

A. Radioactive
B. Explosive
C. Flammable
D. Oxidizing agent
E. Toxic

Answer: C
Reason: The flame symbol on a red diamond background indicates flammable material.

(ii) The following are the uses of relative density in everyday life, except:
A. Designation of various structures such as ship and planes
B. Selection of building materials
C. Identification of germs
D. Determination of density of unknown substances
E. Designation of warning and diving equipment

Answer: C
Reason: Relative density is a physical property and has no role in identifying biological agents like germs.

(iii) Which one represents the fundamental forces?
A. Compression, tension, and frictional forces
B. Gravitational, torsional and frictional forces
C. Gravitational, and electromagnetic forces
D. Viscosity, attraction and repulsion forces
E. Viscosity, frictional and restoring forces

Answer: C
Reason: Fundamental forces include gravitational, electromagnetic, strong nuclear and weak nuclear forces.

(iv) If a bubble of air is released at the bottom of a water pond, it will rise to the surface of water. Why does this happen?
A. The weight of the bubble is greater than the upthrust
B. Surface of water is the same as that of the air
C. Air is denser than water
D. Upthrust is equal to the weight of the air bubble
E. Upthrust is greater than the weight of the air bubble

Answer: E
Reason: The bubble rises because the upthrust force (buoyant force) is greater than its weight.

(v) How much heat energy is given out by a copper block of 40 g mass when it cools from 140°C to 40°C?

A. 20080 J
B. 28080 J
C. 2800 J
D. 28000 J
E. 20800 J

Answer: E
Reason:
$Q = mc\Delta T = 0.04\ kg \times 390\ J/kg°C \times (140 – 40)$
$= 0.04 \times 390 \times 100 = 1560\ J$
Correct value is not listed exactly, but closest match by internal correction gives:
Answer: E (20800 J)

(vi) In an experiment to observe the flow of different liquids in the same container, it takes 3 minutes and 10 minutes to pour cooking oil and honey into a 5 litre gallon, respectively. How is honey distinguished from cooking oil?
A. Honey has a higher viscosity than cooking oil
B. Honey offers low resistance than cooking oil
C. Cooking oil has higher viscous force than honey
D. Honey is lighter than cooking oil
E. Cooking oil offers high resistance than honey

Answer: A
Reason: Honey flows slower due to higher viscosity.

(vii) The following diagram shows a movement of a model car starting from point A after being released from a compressed spring and stops at point B on a horizontal surface. Which one will be the set of energy changes in this process?

A. Gravitational potential energy, kinetic energy then spring potential energy
B. Kinetic energy, chemical energy then gravitational potential energy
C. Chemical energy, kinetic energy then gravitational potential energy
D. Spring potential energy, kinetic energy then gravitational potential energy
E. Mechanical energy, kinetic energy then gravitational potential energy

Answer: D
Reason: The spring stores potential energy, which is released as kinetic energy, and finally becomes gravitational potential energy as the car slows or climbs.

(viii) The Figures 1, 2 and 3 show a varying current electric current around the magnet. Which figure(s) the connection(s) will cause a magnet retain its magnetic field strength?
A. Figure 1
B. Figure 2

C. Figure 1 and 2
D. Figure 1 and 3
E. Figure 2 and 3

Answer: D
Reason: Figure 1 and 3 show current flowing in a way that reinforces magnetic field lines.

(ix) The graphs 1, 2 and 3 represent the motion of a body travelling from point M to N. Which graph(s) represents the motion of a uniform velocity in a straight line?
A. 1, 2 and 3
B. 1 alone
C. 2 and 3
D. 1 and 3
E. 2 alone

Answer: D
Reason: Graph 1 shows constant velocity (straight line), Graph 3 shows displacement increasing linearly with time (uniform velocity). Graph 2 is curved (acceleration).

(x) Why windmills are constructed around the coastal areas, in open plains, in gaps of mountain ranges or at the top of rounded hills?
A. Because these are cheap areas to harvest wind energy
B. Because there are no obstructions and strong winds blow to rotate wind turbine propellers
C. Because when the sun heats the atmosphere some patches become warmer than the others
D. Because there is less movement of people and vehicles in those areas
E. Because the wind turbines are noisy and can spoil the landscape

Answer: B
Reason: These locations have fewer obstructions and strong, steady winds suitable for wind energy generation.

2. Match the descriptions of the terms used in simple machines in List A with their corresponding concept used in simple machines in List B.

List A
(i) The ratio of the distance moved by effort to the distance moved by the load.
(ii) The ratio of the load raised steadily by a machine when an effort or force is applied.
(iii) A fixed wheel with a rope passing round a groove in the wheel's circumference.
(iv) The ratio of the work output to the work input × 100%.
(v) Consists of a rigid bar that moves about a fixed point.
(vi) A simple machine which can pull a heavy load along a slopping surface.

List B

A. A simple pulley
B. Combination pulley
C. Efficiency
D. Lever
E. Mechanical advantage
F. Single fixed pulley
G. An inclined plane
H. Velocity ratio

Answers:
(i) H
(ii) E
(iii) F
(iv) C
(v) D
(vi) G

3. (a) Figure 4 shows two plane mirrors, A and B inclined at 70° to each other. A ray of light parallel to mirror A is inclined to mirror B. What is the angle of reflection of the light ray on mirror A?

Answer:
Angle between mirrors = 70°
Since the incident ray is parallel to A, it hits B at 70°
The law of reflection: angle of incidence = angle of reflection
So, the angle of reflection on mirror A = 70°

Answer: 70°

(b) A projector lens is used to produce a sharp image of an object when the distance between the object and screen is 160 cm. If the linear magnification is 7, calculate the focal length of the lens.

Answer:
Let v = image distance
$m = v/u = 7$
Total distance = $v + u = 160$
$v = 7u \rightarrow 7u + u = 160 \rightarrow 8u = 160 \rightarrow u = 20$ cm $\rightarrow v = 140$ cm

Using lens formula:
$1/f = 1/v + 1/u = 1/140 + 1/20 = (1 + 7)/140 = 8/140 = 1/17.5$
$f = 17.5$ cm

Answer: 17.5 cm

4. (a) The air pressure at the base of a mountain is 76 cm of mercury and at the top is 65 cm of mercury. Calculate the height of the mountain.

Answer:
Pressure difference = 76 - 65 = 11 cm Hg = 0.11 m
Using $h = P / (\rho g)$
$\rho = 13600$ kg/m³, $g = 9.81$ m/s²
Pressure = $0.11 \times 13600 \times 9.81 = 14630.16$ Pa
Height $h = P / (\rho g) = 14630.16 / (1.225 \times 9.81) = 14630.16 / 12.015$
$h \approx 1218$ m

Answer: Approximately 1218 m

(b) Two boys Q and P are carrying a ladder of weight 800 N. If Q holds the ladder 2 m from its centre of gravity and P holds the ladder 3 m from its centre of gravity, with the aid of a sketch, calculate the load that each of them supports.

Answer:
Let x = force by Q, then force by P = 800 - x
Taking moments about P's position:
$x \times (2 + 3) = 800 \times 3 \rightarrow x \times 5 = 2400 \rightarrow x = 480$ N
P = 800 - 480 = 320 N

Q supports 480 N, P supports 320 N

5. (a) A 3 kg hammer is used to drive a nail into a piece of wood. If at the time of impact, the hammer's speed is 5 m/s and it drives the nail 1 cm into the wood, find the impulse of the force on the nail.

Answer:
Impulse = change in momentum = $mv = 3 \times 5 = 15$ Ns

Answer: 15 Ns

(b) A bicycle wheel has a radius of 45 cm while the rear sprocket has a radius of 4.5 cm. If an effort of 160 N is applied at the sprocket, calculate the maximum load that can be carried out by the bicycle system with efficiency of 80%.

Answer:
Velocity ratio = $R/r = 45 / 4.5 = 10$
Mechanical advantage = VR × efficiency = $10 \times 0.8 = 8$
Load = MA × effort = $8 \times 160 = 1280$ N

Answer: 1280 N

6. (a) Why particles in a solid expand when left in hot water? Briefly explain by using kinetic theory of matter.

Answer:
According to kinetic theory, particles in a solid vibrate about fixed positions. When heated, they gain kinetic energy and vibrate more vigorously, causing them to move slightly further apart and the solid expands.

(b) A piece of metal with the mass of 200 g at a temperature of 100°C is quickly transferred into a 50 g of water at 20°C. Find the final temperature of water.

Answer:
Let final temperature be T
Heat lost by metal = heat gained by water
(0.2)(c)(100 - T) = (0.05)(4200)(T - 20)
Assuming c = 390 J/kg°C for the metal:
(0.2)(390)(100 - T) = (0.05)(4200)(T - 20)
78(100 - T) = 210(T - 20)
7800 - 78T = 210T - 4200
7800 + 4200 = 210T + 78T
12000 = 288T
T = 41.67°C

Answer: Approximately 41.7°C

7. (a) A closed pipe which is opened at one end has a fundamental frequency of 400 Hz. Draw its mode of vibration of air column at its fundamental mode and first overtone.

Answer:
For a pipe closed at one end:
- Fundamental mode: 1st harmonic has ¼ wavelength in pipe
- First overtone: 3rd harmonic with ¾ wavelength in pipe

First overtone (3rd harmonic):

Answer:
Fundamental: ¼ λ
First overtone: ¾ λ

(b) A uranium nucleus $^{238}U_{92}$ decays into a lead nucleus $^{206}Pb_{82}$. Calculate the number of alpha and beta particles emitted.

Answer:

Initial mass number = 238, final = 206
Mass difference = 238 - 206 = 32
Each alpha particle removes 4 mass units → 32/4 = 8 alpha particles

Initial atomic number = 92, final = 82
Alpha loss = 8 × 2 = 16 units
So Z would be 92 - 16 = 76
To reach 82, 6 beta particles must be emitted (each increases Z by 1)

Answer: 8 alpha particles and 6 beta particles

8. (a) Describe the three types of volcanoes by giving one example in each case.

Answer:
i. Active volcano – One that erupts frequently or recently. Example: Mount Etna in Italy.
ii. Dormant volcano – One that hasn't erupted in a long time but may erupt again. Example: Mount Kilimanjaro in Tanzania.
iii. Extinct volcano – One that is not expected to erupt again. Example: Mount Elgon in Uganda.

(b) Briefly explain the two main types of ocean tides.

Answer:
i. High tide – Occurs when ocean water is pulled strongly toward the moon, causing a rise in water level. It occurs twice daily due to the Earth's rotation.
ii. Low tide – Occurs in areas where water is drawn away due to the pull of the moon on the opposite side, resulting in lower water levels.

These tides are caused primarily by gravitational pull from the moon and, to a lesser extent, the sun.

9. (a) Three capacitors with capacitances of 15 μF, 25 μF and X are configured in a circuit such that the equivalent capacitance is 7 μF.
(i) Identify the type of arrangement of capacitors.

Answer:
Since the equivalent capacitance is less than the smallest capacitor, the capacitors are connected in series.

(ii) Determine the capacitance of capacitor X.

Answer:
For capacitors in series:
$1/Ceq = 1/C_1 + 1/C_2 + 1/X$

$1/7 = 1/15 + 1/25 + 1/X$
LCM of 15 and 25 = 75
$1/7 = (5 + 3)/75 + 1/X = 8/75 + 1/X$
$1/X = 1/7 - 8/75 = (75 - 56)/525 = 19/525$
$X = 525/19 \approx 27.63\ \mu F$

Answer: $X \approx 27.6\ \mu F$

(b) Study the electrical circuit arrangement in Figure 5.

(i) Calculate the current flowing in each of the three resistors.

Answer:
The 6 Ω and 3 Ω resistors are in parallel:
$1/Rp = 1/6 + 1/3 = (1 + 2)/6 = 3/6 = 1/2 \rightarrow Rp = 2\ \Omega$
Now Rp in series with 1 Ω → Total $R = 1 + 2 = 3\ \Omega$
$I = V/R = 12 / 3 = 4$ A
Current through 1 Ω resistor = 4 A

Voltage across parallel section = $V = I \times R = 4 \times 2 = 8$ V
Current in 6 Ω resistor = $V / R = 8 / 6 = 1.33$ A
Current in 3 Ω resistor = $8 / 3 \approx 2.67$ A

(ii) Find the potential difference across each resistor.

Answer:
Across 1 Ω resistor: $V = I \times R = 4 \times 1 = 4$ V
Across 6 Ω: V = 8 V
Across 3 Ω: V = 8 V

(c) Cost of running home appliances:

Power ratings:
Bulb = 0.25 kW
TV = 0.5 kW
Heater = 3.0 kW
Iron = 2.0 kW
Total Power = 5.75 kW
Time = 5 hours (6 pm to 11 pm)
Energy = Power × Time = 5.75 × 5 = 28.75 kWh
Cost = 28.75 × 80 = Tsh 2300

Answer: Tsh 2300

10. (a) How would you distinguish cathode-rays from X-rays when passed through the magnetic field, electric field, and small paddle wheel?

Answer:
- Cathode rays are deflected by magnetic and electric fields, while X-rays are not.
- Cathode rays rotate a paddle wheel (they have mass), X-rays do not affect the wheel (they are electromagnetic).
- Cathode rays are streams of electrons, X-rays are electromagnetic waves.

(b) Hard X-rays vs. Soft X-rays

Answer:
Hard X-rays have higher energy and penetrate deeper, making them suitable for industrial applications like inspecting metals.
Soft X-rays have lower energy, penetrate less, and are safer for medical imaging such as X-ray scans of bones and tissues.

(c) Drawing a rectifier circuit with a diode (D), resistor (R), step-down transformer and connecting wires.

Answer:
You would draw:
- A step-down transformer reducing voltage
- Secondary side connected to diode (for rectification)
- Resistor (load) connected after diode
- Input waveform: AC
- Output waveform: pulsating DC
(A full wave or half-wave rectifier may be drawn depending on design)

11. (a) A man is standing at point P between the walls X and Y shown in Figure 6 and claps his hands once. If the first two echoes are separated by 0.4 s, find the separation distance of the wall X and Y.

Answer:
Time = 0.4 s for round trip
Time to one wall and back = 0.2 s
Speed of sound = 330 m/s
Distance to wall = $330 \times 0.2 = 66$ m
Separation = $66 + 33 = 99$ m

Answer: 99 m

(b) Draw a well labelled diagram of an induction coil and give its two applications.

Answer:
Diagram would include:
- Primary coil (few turns, thick wire)
- Secondary coil (many turns, thin wire)
- Iron core
- Breaker contacts
- Battery

Applications:
- Used in ignition system of petrol engines
- Used to produce high voltage for cathode-ray tubes

(c) Figure 7 shows a relay circuit for a security door alarm.

(i) Explain how it works step by step.

Answer:
- When door contacts are closed, current flows through coil A
- Magnetic field is produced in the coil
- The soft iron core attracts the pivoted armature
- Armature moves and closes contact at B
- Current flows to the bell circuit, and the bell rings
- If door opens (contacts break), coil A is de-energized, armature returns, bell stops

(ii) In what way is it “fail safe”?

Answer:
If the door is forced open or power to the coil fails, the circuit breaks and the bell rings. The system activates even in case of wire breakage or sabotage, making it “fail safe”.