December 2018

BASIC PHYSICS

Time Allowed: 3 Hours *Full Marks: 70*

Answer to Question No.1 is compulsory and to be answered first.
This answer is to be made in separate loose script(s) provided for the purpose.
Maximum time allowed is 45 minutes, after which the loose answer scripts will be collected and fresh answer scripts for answering the remaining part of the question will be provided.
On early submission of answer scripts of Question No.1,
a student will get the remaining script earlier.
Answer questions from Group-A & B, as directed.

1. Choose the correct answer from the given alternatives: 20x1

i) The percentage error in the measurement of surface area of a sphere is 4.0%. The percentage error in the measurement of its volume is – (a) 2.0%, (b) 4.0%, (c) 6.0%, (d) 8.0%.

ii) Which of the following physical quantities does not have dimensions but has unit? – (a) Specific gravity, (b) Strain, (c) Solid angle, (d) None of these.

iii) A spring of length L and spring constant K is cut into three parts of equal length. The spring constant of each part is – (a) 3K, (b) K/3, (c) K, (d) KL/3.

iv) The SI unit of Poisson's ratio is – (a) N, (b) Nm^2, (c) N/m^2, (d) None of these.

v) If E be the potential energy of the free surface of a liquid, A be its free surface area and S be the surface tension of the liquid then – (a) S = E, (b) S = E/A, (c) S = E A, (d) $S = E A^2$.

vi) A body of mass 1.5 kg floats in water with $(2/3)^{rd}$ of its volume immersed in water. The buoyant force acting on the body is – (a) 9.8 N, (b) 14.7 N, (c) 22.05 N, (d) zero.

vii) The density of a substance is 2700 kg/m^3. Its specific gravity (or relative density) is – (a) 2700, (b) 270, (c) 27, (d) 2.7.

viii) The SI unit of coefficient of viscosity is – (a) poise, (b) decapoise, (c) pascal, (d) bar.

ix) The relation between the coefficient of superficial expansion (β) and the coefficient of volume expansion (Υ) of a substance is – (a) $\Upsilon = (2/3)\beta$, (b) $\Upsilon = (3/2)\beta$, (c) $\Upsilon = 2\beta$, (d) $\Upsilon = 3\beta$.

x) The SI unit of molar specific heat is – (a) calmol K^{-1}, (b) $calmol^{-1}$ K^{-1}, (c) $Jmol^{-1}$ K^{-1}, (d) J mol K^{-1}.

xi) The ratio of molar specific heat at constant pressure and that at constant volume of a diatomic gas is – (a) 1.67, (b) 1.4, (c) 1.33, (d) 1.11.

xii) If 10 J of heat energy be supplied to a system and 15 J of work is done on the system, the increase of internal energy of the system is – (a) –5 J, (b) 5 J, (c) –25 J, (d) 25 J.

xiii) The SI unit of luminous flux is – (a) candela, (b) lux, (c) lumen, (d) none of these.

xiv) The speed of light in glass of refractive index 1.5 is (given, speed of light in vacuum is 3.0 X $10^8 ms^{-1}$) – (a) 2.0 X $10^8 ms^{-1}$ (b) 4.5 X $10^8 ms^{-1}$ (c) 0.22 X $10^8 ms^{-1}$ (d) 3.0 X $10^8 ms^{-1}$.

xv) The transmission of light through optical fibre is based on – (a) refraction of light, (b) reflection of light, (c) total internal reflection of light, (c) interference of light.

xvi) The powers of two thin lenses are + 4 D and – 8 D. The focal length of a combination of these two lenses in contact is (a) – 25.0 cm (b) + 25.0 cm (c) – 25.0 m(d) + 25.0 m.

xvii) A virtual image is formed by a convex lens when the object lies (f = focal length) – (a) on focus (b) between f and 2f(c) between 2f and infinity(d) between optical centre and focus.

xviii) If $\Delta\varphi$ be the phase difference and Δx be the corresponding optical path difference between two light waves of wavelength λ, then – (a) $\Delta\varphi = (\pi/\lambda)\,\Delta x$ (b) $\Delta\varphi = (2\pi/\lambda)\,\Delta x$(c) $\Delta\varphi = (\lambda/\pi)\,\Delta x$(d) $\Delta\varphi = (\lambda/2\pi)\,\Delta x$.

xix) The saturation current in a photoelectric cell increases if – (a) the frequency of the incident radiation is decreased, (b) the frequency of the incident radiation is increased, (c) the intensity of the incident radiation is decreased, (d) the intensity of the incident radiation is increased.

xx) The momentum (p) of a photon associated with a light of wavelength λ is (h = Planck's constant) – (a) $p = h\lambda$ (b) $p = h/\lambda$ (c) $p = \lambda/h$ (d) $p = h/\lambda^2$.

Group-A

Answer any three questions.

2. a) What do you mean by the dimensions of a physical quantity? Illustrate with an example.
   b) Check by dimensional analysis whether the physical equation h = rρg/2T is correct or not, where h is the height of liquid column in a capillary tube of radius r;ρ& T are the density and surface tension of the liquid respectively and g is the acceleration due to gravity. If not, can you guess the correct equation by dimensional logic?
   c) Mention the applications of dimensional analysis.
   d) Define absolute error and proportional error in respect to measurement of physical quantities. (1½+1½)+(2+1)+2+2

3. a) Mention the factors on which the modulus of elasticity of a substance depends.
   b) Define surface tension. Write down its SI unit in terms of the unit of energy.
   c) The volume of a gas at a pressure of 76 cm of Hg is 200 cc. It is found that if the pressure of the gas is decreased by 3 mm of Hg at constant temperature, the volume increases by 0.4 cc. Calculate the bulk modulus of the gas and its compressibility in SI unit. Density of mercury = 13.6 g cm^{-3} and g = 9.8 ms^{-2}). 2+(2+1)+5

4. a) Write down the conditions of equilibrium of a floating body.
   b) What is streamline flow of a fluid? Give the statement of equation of continuity in respect to the flow of a fluid. Which conservation principle does it stand for?
   c) A body of external volume 40 cm^3 has a cavity inside it. The body is found to float in water in fully immersed condition. If the specific gravity of the material of the body be 1.5, find the volume of the cavity. 2+(1+1+1)+5

5. a) Define coefficient of viscosity of a fluid. Write down the mathematical form of Stoke's law in respect to the viscous force.
   b) Name a substance whose expansion with the rise of temperature is almost zero. Pendulum clock goes fast in winter and slow in summer – explain.
   c) A copper rod and a brass rod of lengths 6 cm and 4 cm respectively and of same cross-sectional area50 $cm^2$are joined in series to form a composite rod. The temperatures of the free end of the copper rod and that of the brass rod are 150^0C and 30^0C respectively. Find the temperature at the junction of the rods and the amount of heat flowing through the composite rod per second. The thermal conductivities of copper and brass are 386 $Wm^{-1}K^{-1}$ and 260 $Wm^{-1}K^{-1}$ respectively. 2+(1+2)+5

6. a) Write down the differences between isothermal and adiabatic process.
   b) State zeroth law of thermodynamics. How does the internal energy of a gas change with the change of its temperature?
   c) Draw pressure vs temperature curve for isochoric process and volume vs temperature curve for isobaric process.

d) The density of platinum at 400^0C is 2120 kg m^{-3}. Find its density at 30^0C. Given, coefficient of linear expansion of platinum is $9.0 \times 10^{-6} K^{-1}$. 3+(1+1)+(1+1)+3

Group-B

Answer any two questions.

7. a) Define illuminance at a point on a surface. State the principle of photometry.
   b) State inverse square law of photometry.
   c) A point source of light of luminous intensity 100 cd is hanging vertically at a height of 4.0 m above the centre of a circular table of radius 2.0 m. Calculate the illuminance at the centre and at the edge of the table. (1½+1½)+2+5

8. a) Write down the conditions for total internal reflection of light.
   b) Define critical angle for a pair of media. On what factors does it depend?
   c) A ray of light passes from vacuum to a medium of refractive index μ. If the angle if incidence – (i) be twice the angle of refraction, prove that $i = 2\cos^{-1}(\mu/2)$.
   d) Define with ray diagram the second principal focus of a convex lens. 2+(2+2)+2+2

9. a) The focal length of an equi-convex lens of refractive index 1.5 in air is 20 cm. Using lens maker's formula find the value of radius of curvature of the lens.
   b) What is the shape of wave-front for a very long line source of light? State Huygens' Principle of propagation of wave-front.
   c) Derive the expression for the fringe width in Young's double slit experiment. 2+(1+2)+5

10. a) Define threshold frequency in photoelectric effect.
    b) What is Einstein's quantization idea? Write down Einstein's photoelectric equation with the meaning of symbols used. Using this equation express stopping potential (V_s) in terms of frequency (ν) of incident radiation. Draw the curve showing the variation of V_s with ν. Explain how the values of Planck's constant and work function can be determined from the graph. 2+(1+2+1+1+3)