Measurements and Errors

2010

1. **A capillary tube is attached horizontally to a constant heat arrangement. If the radius of the capillary tube is increased by 10%, then the rate of flow of liquid will change nearly by**

   a) +10% b) +46% c) -10% d) -40%

2. **If momentum is increased by 20%, then kinetic energy increases by**

   a) 48% b) 44% c) 40% d) 36%

3. **If increase in linear momentum of a body is 50%, then change in its kinetic energy is**

   a) 25% b) 125% c) 150% d) 50%

4. **Choose the incorrect statement out of the following.**

   a) Every measurement by any measuring instrument has some errors.

   b) Every calculated physical quantity that is based on measured values has some error.

   c) A measurement can have more accuracy but less precision and vice versa.

   d) The percentage error is different from relative error.

2009

5. **By what percentage should the pressure of a given mass of a gas be increased, so as to decrease its volume by 10% at a constant temperature?**

   a) 5% b) 7.2% c) 12.5% d) 11.1%

6. **Percentage error in the measurement of mass and speed are 2% and 3% respectively. The error in the estimation of kinetic energy obtained by measuring mass and speed will be**

   a) 12% b) 10% c) 2% d) 8%.

2008

7. If the error in the measurement of radius of a sphere is 2%, then the error in the determination of volume of the sphere will be

a) 4$ b) 6% c) 8% d) 2%

8. Assertion: The error in the measurement of radius of the sphere is 0.3%. The permissible error in its surface area is 0.6%.

Reason: The permissible error is calculated by the formula $\frac{\Delta A}{A} = \frac{4\Delta r}{r}$.

a) Both assertion and reason are true reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

9. The period of oscillation of a simple pendulum in the experiment is recorded as 2.63s, 2.56s, 2.42s, 2.71s and 2.80s respectively. The average absolute error is

a) 0.1s b) 0.11s c) 0.01s d) 1.0s

2007

10. A wire has a mass (0.3 ± 0.003) **g, radius** (0.5 ± 0.005) **mm and length** (6 ± 0.006) **cm. The maximum percentage error in the measurement of its density**

a) 1 b) 2 c) 3 d) 4

11. If voltage $V = (100 \pm 5)$ **volt and current** $I = (10 \pm 0.2)$ **A, the percentage error in resistance R is**

a) 5.2% b) 25% c) 7% d) 10%

2005

12. If radius of the sphere is $(5.3 \pm 0.1)cm$ **. Then percentage error in its volume will be**

a) $3 + 6.01 \times \frac{100}{5.3}$ b) $\frac{1}{3} + 0.01 \times \frac{100}{5.3}$ c) $\left(\frac{3 \times 0.1}{5.3}\right) \times 100$ d) $\frac{0.1}{5.3} \times 100$

13. The radius of sphere is measured to be (2.1 ± 0.5) cm. Calculate its surface area with error limits

a) $(55.4 \pm 26.4)cm^2$ b) $(55.4 \pm 0.02)cm^2$ c) $(55.4 \pm 2.64)cm^2$ d) $(55.4 \pm 0.26)cm^2$

14. If the length of rod A is $3.25 \pm 0.01cm$ and that of B is $4.19 \pm 0.01cm$. Then the rod B is longer than rod A by

a) $0.94 \pm 0.00cm$ b) $0.94 \pm 0.01cm$ c) $0.94 \pm 0.02cm$ d) $0.94 \pm 0.005cm$

2004

15. A force F is applied on a square plate of side L. If percentage error in determination of L is 2% and that in F is 4%, permissible error in pressure is

a) 2% b) 4% c) 6% d) 8%

2003

16. The value of two resistors are $R_1 = (6 \pm 0.3)k\Omega$ and $R_2 = (10 \pm 0.2)k\Omega$. The percentage error in the equivalent resistance when they are connected in parallel is

a) 5.125% b) 2% c) 10.125% d) 7%

17. The difference in the lengths of a mean solar day and a sidereal day is about

a) 1 min b) 4 min c) 15 min d) 56 min

Key

1) **b**	2) **b**								
3) **b**	4) **d**	5) **d**	6) **d**	7) **b**	8) **c**	9) **b**	10) **d**	11) **c**	12) **c**
13) **a**	14) **c**	15) **d**	16) **c**	17) **b**					

Hints

1. Volume of liquid coming out of the tube of per second

$$\Rightarrow V = \frac{p\pi r^4}{8\eta l}$$

$$\Rightarrow \frac{V_2}{V_1} = \left[\frac{r_2}{r_1}\right]^{-4}$$

$$\Rightarrow V_2 = V_1\left[\frac{110}{100}\right]^4$$

$$\Rightarrow V_2 = V_1\left[\frac{110}{100}\right]^4$$

$$= V_1(1.1)^4 = 1.4641 volt$$

$$\Rightarrow \frac{\Delta V}{V} = \frac{V_2 - V_1}{V} = \frac{1.4641 - V}{V} = 46\%$$

2. The kinetic energy is given by $KE = \frac{p^2}{2m}$

So, $\Delta KE = \frac{2p\Delta p}{2m} = \frac{p\Delta p}{m}$

$$\Rightarrow \frac{4KE}{KE} = \frac{2\Delta p}{p}$$

Thus, the final momentum becomes 1.2p

So, percentage change in $KE = \frac{final\ KE - initial\ KE}{initial\ KE} \times 100$

$$= \frac{1.44(p^2/2m) - (p^2/2m)}{(p^2/2m)} = 44\%$$

3. We know that linear momentum $p = \sqrt{2mK}$

Now we have $p_1 = p,\ p_2 = p_1 + 50\%$ of $p_1 = 1.5p_1$

$$\Rightarrow \frac{K_1}{K_2} = \frac{p_1^2}{p_2^2} \Rightarrow K_2 = \frac{p_2^2}{p_1^2}K_1 = 2.25K$$

So change in KE = 2.25 – 1 = 125%

5. When T is constant, pV = constant. When volume is decreased by 10% that is volume becomes $\frac{90}{100}$, the pressure must become 100/99. Thus percentage increase in pressure

$= \frac{(100-90)\times 100}{90}$

= 11.1%

6. Kinetic energy $K = \frac{1}{2}mv^2$

Fractional error in kinetic energy

$\frac{\Delta K}{K} = \frac{\Delta m}{m} + \frac{2\Delta v}{v}$

Percentage error in kinetic energy is

$= \frac{\Delta m}{m}\times 100 + \frac{2\Delta v}{v}\times 100$

As we know, $\frac{\Delta m}{m}\times 100 = 2\%$ and $\frac{\Delta v}{v}\times 100 = 3\%$

So, percentage error in kinetic energy

= 2 + 2 x 3 = 2 + 6 = 8%

7. Volume of a sphere $= \frac{4}{3}\pi(radius)^3$

Or $V = \frac{4}{3}\pi R^3$

Taking logarithm on both sides, we have

$\log V = \log\frac{4}{3}\pi + 3\log R$

Differentiating, we get $\frac{\Delta V}{V} = 0 + \frac{3\Delta R}{R}$

Accordingly, $\frac{\Delta R}{R} = 2\%$

$\therefore \frac{\Delta V}{V} = 3\times 2\% = 6\%$

9. Average value $= \frac{2.63+2.56+2.42+2.71+2.80}{5}$

$= 2.62s$

Now, $|\Delta T_1| = 2.63 - 2.62 = 0.01$

$|\Delta T_2| = 2.62 - 2.56 = 0.06$

$|\Delta T_3| = 2.62 - 2.42 = 0.20$

$|\Delta T_4| = 2.71 - 2.62 = 0.09$

$|\Delta T_5| = 2.80 - 2.62 = 0.18$

$\Delta T = \frac{|\Delta T_1| + |\Delta T_2| + |\Delta T_3| + |\Delta T_4| + |\Delta T_5|}{5}$

$= \frac{0.54}{5} = 0.11s$

10. Density $\rho = \frac{m}{\pi r^2 L}$

$\therefore \frac{\Delta\rho}{\rho} \times 100 = \left[\frac{\Delta m}{m} + \frac{2\Delta r}{r} + \frac{\Delta L}{L}\right] \times 100$

After substituting the values, we get the maximum percentage error in density = 4%

11. Given, voltage $V = (100 \pm 5) volt$,

Current $I = (10 \pm 0.2) A$

From ohm's law V = IR

$\therefore$ Resistance $R = \frac{V}{I}$

Maximum percentage error in resistance

$\left(\frac{\Delta R}{R} \times 100\right) = \left(\frac{\Delta V}{V} \times 100\right) + \left(\frac{\Delta I}{I} \times 100\right)$

$= \left(\frac{5}{100} \times 100\right) + \left(\frac{0.2}{10} \times 100\right)$

= 5 + 2 = 7%

12. Volume of sphere $(V) = \frac{4}{3}\pi r^3$

% error in volume $= \frac{3 \times \Delta r}{r} \times 100$

$= \left(\frac{3 \times 0.1}{5.3}\right) \times 100$

13. Surface area

$S = 4\pi r^2 = 4 \times \frac{22}{7} \times (2.1)^2 = 55.44 = 55.4 cm^2$

Further, $\frac{\Delta S}{S} = 2.\frac{\Delta r}{r}$

Or $\Delta S = 2\left(\frac{\Delta r}{r}\right)(S)$

$= \frac{2 \times 0.5 \times 55.4}{2.1} = 26.38 = 26.4 cm^2$

$\therefore S = (55.4 \pm 26.4) cm^2$

14. Length of rod A is $L_A = 3.25 \pm 0.01$

And that of B is $L_B = 4.19 \pm 0.01$

Then, the rod B is longer than rod A by a length

$\Delta l = L_B - L_A$

$\Delta l = (4.19 \pm 0.01) - (3.25 \pm 0.01)$

$\Delta l = (0.94 \pm 0.02) cm$

15. Pressure $= \frac{force}{area} = \frac{F}{L^2}$

$\therefore \frac{dp}{p} \times 100 = \left(\frac{dF}{F} + \frac{2dL}{L}\right) \times 100$

= 4 + 2 x 2 = 8%

16. $R_{parallel} = \frac{R_1 R_2}{R_1 + R_2}$

$$\Rightarrow \frac{\Delta R_p}{R_p} = \frac{\Delta R_1}{R_1} + \frac{\Delta R_2}{R_2} + \frac{\Delta (R_1 + R_2)}{R_1 + R_2}$$

$$\Rightarrow \frac{\Delta R_p}{R_p} = \frac{0.3}{6} + \frac{0.2}{10} + \frac{0.3 + 0.2}{10 + 6}$$

$$\therefore \frac{\Delta R_p}{R_p} \times 100 = 10.125\%$$

17. Sidereal day is about 4 min shorter than our normal solar 24h or one day. It is about 3 min 56s.