Thermal Properties of Matter

Thermometry

2009

1. A constant volume gas thermometer works on

a) Archimedes principle
b) Pascal's law
c) Boyle's law
d) Charley's law

2008

2. On a new scale of temperature (which is linear) and called the W scale, the freezing and boiling points of water are $39^0 W$ and $239^0 W$ respectively. What will be the temperature on the new scale, corresponding to a temperature of $39^0 W$ on the Celsius Scale?

a) $78^0 W$
b) $117^0 W$
c) $200^0 W$
d) $139^0 W$

3. Mercury boils at $367^0 C$. However, mercury thermometers are made such that they can measure temperature up to $500^0 C$. This is done by

a) Maintaining vacuum above mercury column in the stem of the thermometer
b) Filling nitrogen gas at high pressure above the mercury column
c) Filling oxygen gas at high pressure above the mercury column
d) Filling nitrogen gas at low pressure above the mercury column

4. Two thermometers are constructed in the same way excepted that one has a spherical bulb and the other a cylindrical bulb, which one will respond quickly to temperature changes

a) Spherical Bulb Thermometer
b) Cylindrical Bulb Thermometer
c) Both Equally
d) None of the Above

2006

5. **If boiling point of water is $95^0 F$, water will be reduction at Celsius scale**

a) $7^0 C$ b) $65^0 C$ c) $63^0 C$ d) $35^0 C$

2004

6. **If a thermometer reads freezing point of water as $20^0 C$ and boiling point as $150^0 C$, how much thermometer read, when the actual temperature is $60^0 C$**

a) $98^0 C$ b) $110^0 C$ c) $40^0 C$ d) $60^0 C$

7. **A Centigrade and Fahrenheit thermometers are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers a temperature of $140^0 C$. The fall of temperature as registered by the Centigrade thermometer is**

a) $80^0 C$ b) $40^0 C$ c) $50^0 C$ d) $90^0 C$

2003

8. **Absolute zero is the condition at which**

a) Molecular motion ceases b) Gas becomes liquid

c) Gas cannot be liquefied d) Random motion of molecules occur

Thermal Expansion

2011

9. **During an isothermal expansion, a confined ideal gas does -150J of work against its surroundings. This implies that**

a) 300J of heat has been added to the gas

b) No heat is transferred because the process is isothermal

c) 150J of heat has been added to the gas

d) 150J of heat has been removed from the gas

2010

10. A clock with a metal pendulum beating seconds keeps correct time at 0^0C. If it loses 12.5s a day at 25^0C, the coefficient of linear expansion of metal pendulum is

a) $\frac{1}{86400}/^0C$ b) $\frac{1}{43200}/^0C$ c) $\frac{1}{14400}/^0C$ d) $\frac{1}{28800}/^0C$

2009

11. It is difficult to cook rice in an open vessel by boiling it at high altitudes because of

a) Low boiling because of b) High boiling point and low pressure

c) Low boiling point and low pressure d) High boiling point and high pressure

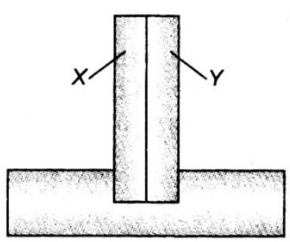
2007

12. Coefficient of cubical expansion of water is zero at

a) 0^0C b) 4^0C c) 15.5^0C d) 100^0C

2006

13. A bimetallic strip consists of metal X and Y. It is mounted rigidly at the base as shown. The metal X has a higher coefficient of expansion compared to that for metal Y. When bimetallic strip is placed in a cold bath



a) It will bend towards the right b) It will bend towards the left

c) It will not be end but shrink d) It will neither bend nor shrink

14. **A vertical column 50cm long at 50^0C balances another column of same liquid 60cm long at 100^0C. The coefficient of absolute expansion of the liquid is**

a) $0.005/{}^0C$ b) $0.0005/{}^0C$ c) $0.002/{}^0C$ d) $0.0002/{}^0C$

Thermal Conduction and Convection

2010

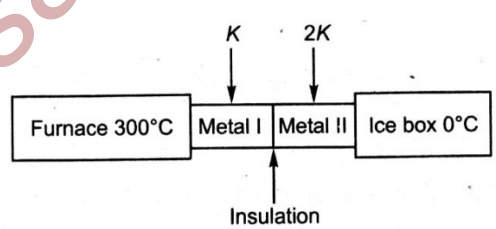
15. **A cylindrical metallic rod in thermal contact with two reservoirs of heat at its two ends conducts an amount of heat Q in time t. The metallic rod is melted and the material is formed into a rod of half the radius of the original rod. What is the amount of heat conducted by the new rod when placed in thermal contact with the two reservoirs in time t**

a) $\frac{Q}{4}$ b) $\frac{Q}{16}$ c) 2Q d) $\frac{Q}{2}$

16. **The coefficient of real expansion of mercury is $0.18\times10^{-3}C^{-1}$. If the density of mercury at 0^0C is 13.6g/cc, its density at 473K will be**

a) 13.12 g/cc b) 13.65 g/cc c) 13.51 g/cc d) 13.22 g/cc

17. **In the diagram, a system of two metals of equal lengths and of same cross-sectional area are joined together**



The coefficients of thermal conductivities of the metals are K and 2K respectively. If the furnace temperature at one end is 300^0C and ice box temperature at the other end is 0^0C, then the junction temperature is

a) 100^0C b) 125^0C c) 150^0C d) 200^0C

2009

18. A cylinder of radius r and of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius r and outer radius 2r made of a material of thermal conductivity K_2. The effective thermal conductivity of the system is

a) $\frac{1}{3}(K_1+2K_2)$ b) $\frac{1}{2}(2K_1+3K_2)$ c) $\frac{1}{3}(3K_2+2K_1)$ d) $\frac{1}{4}(K_1+3K_2)$

19. The two ends of a rod of length L and a uniform cross-sectional area A are kept at two temperatures T_1 and $T_2(T_1>T_2)$.The rate of heat transfer, $\frac{dQ}{dt}$, through the rod in a steady is given by

a) $\frac{dQ}{dt}=\frac{KL(T_1-T_2)}{A}$ b) $\frac{dQ}{dt}=\frac{K(T_1-T_2)}{LA}$ c) $\frac{dQ}{dt}=KLA(T_1-T_2)$ d) $\frac{dQ}{dt}=\frac{KA(T_1-T_2)}{L}$

2008

20. Ice starts freezing in a lake with water at 0^0C when the atmospheric temperature is -10^0C. If the time taken for 1cm of ice to be formed is 12min; the time taken for the thickness of the ice to change from 1cm and 2cm will be

a) 12 min b) Less than 12 min

c) More than 12 min but less than 24min d) More than 24 min

2007

21. Consider a compound slab consisting of two difference materials having equal thickness and thermal conductivities K and 2K respectively. The equivalent thermal conductivity of the slab is

a) 3K b) $\frac{4}{3}K$ c) $\frac{2}{3}K$ d) $\sqrt{2}K$

2006

22. Which of the following circular rods, (given radius r and length l) each made of the same material and whose end are maintained at the same temperature will conduct most heat?

a) $r = 2r_0, l = 2l_0$ b) $r = 2r_0, l = l_0$ c) $r = r_0, l = l_0$ d) $r = r_0, l = 2l_0$

2005

23. Two rods of same material have same length and area. The heat ΔQ flows through them for 12min when they are joined side by side. If now both the rods are joined in parallel, then the same amount of heat ΔQ will flow in

a) 24 min b) 3 min c) 12 min d) 6 min

Radiation (Kirchhoff's Law, Black Body)

2010

24. Assertion (A): Like light radiation, thermal radiations are also electromagnetic radiation.

Reason (R): The thermal radiations require no median for propagation.

a) Both assertion and reason are true and 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.

25. Two blacks metallic spheres of radius 4m, at 2000K and 1m, at 4000K will have ratio of energy radiation as

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

26. **The total radiant energy per unit area normal to the direction of incidence, received at a distance R from the centre of a star of radius r, whose outer surface radiates as a black body at a temperature T K is given by**

a) $\frac{\sigma r^2 T^4}{R^2}$ b) $\frac{\sigma r^2 T^4}{4\pi r^2}$ c) $\frac{\sigma r^4 T^4}{r^4}$ d) $\frac{4\pi\sigma r^2 T^4}{R^2}$

27. **At $273^0 C$, the emissive power of a perfect black body is R. What is its value at $0^0 C$**

a) $\frac{R}{4}$ b) $\frac{R}{16}$ c) $\frac{R}{2}$ d) None of these

2009

28. **A black body at $227^0 C$ radius heat at the rate of 7 cal $cm^{-2} s^{-1}$. At a temperature of $727^0 C$, the rate of heat radiated in the same units will be**

a) 60 b) 50 c) 112 d) 80

29. **The rate of emission of a black body at $0^0 C$ is it rate of emission at $273^0 C$ is**

a) 4R b) 8R c) 16R d) 32R

2007

30. **We consider the radiation emitted by the human body. Which of the following statements is true?**

a) The radiation is emitted during the summers and absorbed during the winters.

b) The radiation emitted lies in the ultraviolet region and hence is not visible.

c) The radiation emitted is in the infrared region.

d) The radiation is emitted only during the day.

2006

31. **Three objects coloured black, gray and white can withstand hostile conditions up to $2800^0 C$. These objects are thrown into a furnace where each of them attains a temperature of $2000^0 C$. Which object will glow brightest?**

a) The white object b) The black object

c) All glow with equal brightness d) Gray object

2005

32. Assertion (A): A body that is a good radiator is also a good absorber of a radiation at a given wavelength.

Reason(R): According to Kirchhoff's law the absorptivity of a body is equal to its emissivity at a given wavelength.

a) Both assertion and reason are true and 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.

2004

33. Mud hoses are cooler in summer and warmer in winter because

a) Mud is a good conductor of heat b) Mud is a superconductor of heat

c) Mud is a bad conductor of heat d) None of these

Radiation (Wien's Law, Stefan's Law and Newton's Law of Cooling)

2010

34. A thin square steel plate with each side equal to 10cm is heated by a blacksmith. The rate radiated energy by the heated plate is 1134W. The temperature of the hot steel plate is (Stefan's constant $\sigma = 5.67\times10^{-8} Wm^{-2}K^{-4}$, emissivity of the plate = 1)

a) 1000K b) 1189K c) 20000K d) 2378 K

35. A hot body at temperature T losses heat to the surrounding temperature T_S by radiation. If the difference in temperature is small then the rate of loss of heat by the hot body is proportional to

a) $(T - T_S)$ b) $(T - T_S)^2$ c) $(T - T_S)^{1/2}$ d) $(T - T_S)^4$

2009

36. The tungsten filament of an electric lamp has surface area A and a power rating P. If the emissivity of the filament is ε and σ is Stefan's constant the steady temperature of the filament will be

a) $T = \left(\frac{P}{A\varepsilon\sigma}\right)^4$ b) $T = \left(\frac{P}{A\varepsilon\sigma}\right)$ c) $T = \left(\frac{A\varepsilon\sigma}{P}\right)^{\frac{1}{4}}$ d) $T = \left(\frac{P}{A\varepsilon\sigma}\right)^{\frac{1}{4}}$

2008

37. Two solid spheres A and B made of the same material have radii r_A and r_B respectively. Both the spheres are cooled from the same temperature under the conditions valid for Newton's law of cooling. The ratio of the rate of change of temperature A and B is

a) $\frac{r_A}{r_B}$ b) $\frac{r_B}{r_A}$ c) $\frac{r_A^2}{r_B^2}$ d) $\frac{r_B^2}{r_A^2}$

2007

38. A black body is at $727^0 C$. It energy at a rate which is proportional to

a) $(727)^2$ b) $(1000)^4$ c) $(1000)^2$ d) $(727)^4$

39. Two friends A and B are waiting for another friend for tea. A took the tea in a cup and mixed the cold milk and then waits. B took the tea in the cup and then mixed the cold milk when the friend comes. Then the tea will be hotter in the cup of

a) A b) B

c) Tea will be equally hot in both cups d) Friend's cup

40. A planet having average surface temperature T_0 at an average distance d from the sun. Assuming that the planet receives radiant energy from the sun only and it loses radiant energy only from the surface and neglecting all other atmospheric effects we conclude

a) $T_0 \propto d^2$ b) $T_0 \propto d^{-2}$ c) $T_0 \propto d^{1/2}$ d) $T_0 \propto d^{-1/2}$

41. A sphere and a cube of same material and same volume are heated up to same temperature and allowed to cod in the same surroundings. The ratio of the amounts of radiation emitted will be

a) 1 : 1 b) $\frac{4}{3}\pi:1$ c) $\left(\frac{\pi}{6}\right)^{1/3}:1$ d) $\frac{1}{2}\left(\frac{4\pi}{3}\right)^{2/3}:1$

2006

42. The surface temperature of the sun is T K and the solar constant for a plate is S. The sun subtends an angle θ at the planet. Then

a) $S \propto T^4$ b) $S \propto T^2$ c) $S \propto \theta^2$ d) $S \propto \theta$

2005

43. Assertion (A): For higher temperature the peak emission wavelength of a black body shifts to lower wavelengths.

Reason (R): A Peak emission wavelength of a black body is proportional to the fourth-power of temperature.

a) Both assertion and reason are true and 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.

49. A body at a temperature of $728^0 C$ and has surface area $5cm^2$, radiates 300J energy each minute. The emissivity is (Given: Boltzmann constant $= 5.67\times10^{-8} Wm^2K^4$)

a) e = 0.18 b) e = 0.02 c) e= 0.2 d) e = 0.15

2004

45. Suppose the sun expands so that its radius becomes 100 times its present radius and its surface temperature becomes half of its present value. The total energy emitted by it, then will increase by a factor of

a) 10^4 b) 625 c) 256 d) 16

46. A black body at 200K is found to exit maximum energy at a wavelength $14\mu m$. When its temperature is raised to 1000K, then wavelength at which maximum energy emitted is

a) 14 mm b) $7\mu m$ c) $2.8\mu m$ d) 28 mm

Key

1) **d**	2) **b**	3) **b**	4) **b**	5) **d**	6) **a**	7) **b**	8) **a**	9) **c**	10) **a**
11) **c**	12) **b**	13) **b**	14) **b**	15) **b**					
16) **a**	17) **a**	18) **d**	19) **d**	20) **d**	21) **b**	22) **b**	23) **b**	24) **b**	25) **a**
26) **a**	27) **b**	28) **c**	29) **c**	30) **c**	31) **b**	32) **a**	33) **c**	34) **b**	
35) **a**	36) **d**	37) **b**	38) **b**	39) **a**	40) **d**	41) **c**	42) **a**	43) **c**	
44) **a**	45) **b**	46) **c**							

Hints

Thermometry

2. $$\frac{39-0}{100-0}=\frac{t-39}{239-39}$$

Or $t=117^0 W$

5. $$T_F=32+\frac{9}{5}T_C$$

Or $T_C=\frac{5}{9}(T_F-32)$

$T_F=95^0 F$

$\therefore T_C=\frac{5}{9}(95-32)=35^0 C$

6. 100 – 60 = $150-\theta$

$\Rightarrow 40=150-\theta$ ……………….(i)

$60-0=\theta-20$

$60=\theta-20$ …………….(ii)

Dividing eq (i) by eq (ii) we get

$$\frac{40}{60}=\frac{150-\theta}{\theta-20}$$

$$\Rightarrow \frac{2}{3}=\frac{150-\theta}{\theta-20}$$

$\Rightarrow \theta=98^0 C$

7. $$\frac{C}{5}=\frac{F-32}{9}$$

$F=140^0 F$

$$\therefore \frac{C}{5}=\frac{140-32}{9}$$

$\Rightarrow C=12\times 5=60^0 C$

$\therefore$ Fall in temperature in centigrade scale $=100^0 C-60^0 C=40^0 C$

Thermal Expansion

9. From first law of thermodynamics

$\Delta U = Q + W$

For isothermal process, $\Delta U = 0$

Q = -W

Given W = - 150

$\therefore Q = +150$

When O is positive, the heat is added to the gas

10. $\Delta t = \frac{1}{2}\alpha \Delta \theta \times 86400$

$\alpha = \frac{2\Delta t}{\Delta \theta \times 86400} = \frac{2 \times 12.5}{25 \times 86400}$

$\alpha = \frac{1}{86400} /^0 C$

14. $\frac{h_1}{h_2} = \frac{\rho_2}{\rho_1} = \frac{(1+\gamma\theta_1)}{(1+\gamma\theta_2)}$ $\left[\because \rho = \frac{\rho_0}{(1+\gamma\theta)}\right]$

$\Rightarrow \frac{50}{60} = \frac{1+\gamma+50}{1+\gamma+100} \Rightarrow 0.005 /^0 C$

Thermal Conduction and Convection

15. $Q = \frac{KA(\theta_1 - \theta_2)t}{l}$ Where K is coefficient of thermal conductivity of material of rod

$\Rightarrow \frac{\alpha}{l} \propto \frac{A}{l} \propto \frac{r^2}{l}$ …………… (i)

As the metallic rod is melted and the material is formed into a rod of half the radius

$V_1 = V_2$

$\pi r_1^2 l_1 = \pi r_2^2 l_2$

$$\Rightarrow l_1 = \frac{l_2}{4} \text{ ....(ii)}$$

Now, from eq (i) and (ii)

$$\frac{Q_1}{Q_2} = \frac{r_1^2}{l_1} \times \frac{l_2}{r_2^2} = \frac{r_1^2}{l_1} \times \frac{4l_1}{(r_1/2)^2}$$

$$\Rightarrow Q_1 = 16Q_2 \Rightarrow Q_2 = \frac{81}{16}$$

16. $t_1 = 0^0C = 273K,\ t_2 = 473K$

$\gamma_r = 0.18 \times 10^{-3} C^{-1}$

$d_1 = 13.6 g/cc$

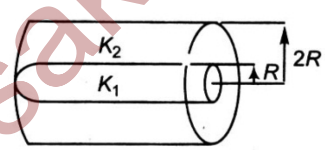
$$d = \frac{d_1}{1+\gamma_r(\Delta t)} = \frac{13.6}{1+0.18\times10^{-3}\times(473-273)}$$

$$d_2 = \frac{13.6}{1.036} = 13.127 \text{ g/cc}$$

17. Temperature of interface

$$\theta = \frac{k_1\theta_1 l_2 + k_2\theta_2 l_1}{k_1 l_1 + k_2 l_2} = \frac{2k\times0\times l + k\times300\times l}{kl+2kl} = 100^0C$$

18. Both the cylinders are in parallel, for the heat flow from one end as shown



Hence, $K_{eq} = \frac{K_1A_1 + K_2A_2}{A_1+A_2}$; where, A , = area of cross-section of inner cylinder $= \pi R^2$ and

A_2 = area of cross-section of cylindrical shell

$= \pi\{(2R)^2 - (R)^2\} = 3\pi R^2$

$$\Rightarrow K_{eq} = \frac{K_1(\pi R^2) + K_2(3\pi R^2)}{\pi R^2 + 3\pi R^2} = \frac{K_1+3K_2}{4}$$

20. $t = \frac{\rho L}{2K\theta} y^2$

$\Delta t_1 : \Delta t_2 : \Delta t_3 :: (1^2 - 0^2) : (2^2 - 1^2) : (3^2 - 2^2)$

Or $\Delta t_1 : \Delta t_2 : \Delta t_3 :: 1 : 3 : 5$

But, $\Delta t_1 = 12\,\text{min}$

$\Delta t_2 = 3\Delta t_1 = 3 \times 12\,\text{min} = 36$ min

21. $K' = \dfrac{2K_1K_2}{K_1 + K_2}$

$K_1 = K, K_2 = 2K$

$\therefore K' = \dfrac{2K \times 2K}{K + 2K} = \dfrac{4}{3}$

22. $H = \dfrac{\Delta Q}{\Delta t} = KA\left(\dfrac{T_1 - T_2}{l}\right)$

$\Rightarrow H \propto \dfrac{r^2}{l}$

a) When $r = 2r_0$, $l = 2l_0$

$H \propto \dfrac{(2r_0)^2}{2l_0} \Rightarrow H \propto \dfrac{2r_0^2}{l_0}$

b) when $r = 2r_0$; $l = l_0$

$H \propto \dfrac{(2r_0)^2}{l_0}$

$\Rightarrow H \propto \dfrac{4r_0^2}{l_0}$

c) When $r = r_0$; $l = l_0$

$H \propto \dfrac{r_0^2}{l_0}$

d) When $r = r_0$, $l = 2l_0$

$H \propto \dfrac{r_0^2}{2l_0}$

23. $\frac{Q}{t}=\frac{KA\Delta\theta}{l}=\frac{\Delta\theta}{(l/KA)}=\frac{\Delta\theta}{R}$ (R = thermal resistance)

$\Rightarrow t\propto R$ ($\because Q$ and $\Delta\theta$ are same)

$\Rightarrow \frac{t_p}{t_s}=\frac{R_p}{R_s}=\frac{R/2}{2R}=\frac{1}{4}$

$\Rightarrow t_p=\frac{t_s}{4}=\frac{12}{4}=3\,\text{min}$

Radiation (Kirchhoff's Law, Black Body)

25. $P=A\varepsilon\sigma T^4$

$\frac{P_1}{P_2}=\frac{A_1}{A_2}\cdot\frac{T_1^4}{T_2^4}=\left(\frac{R_1}{R_2}\right)^2\cdot\left(\frac{T_1}{T_2}\right)^4$ ($\because A=\pi R^2$)

$=\left(\frac{4}{1}\right)^2\times\left(\frac{2000}{4000}\right)^4=\frac{1}{1}$

26. $A\sigma T^4=4\pi r^2\sigma T^4$

$S=\frac{P}{4\pi R^2}=\frac{4\pi r^2\sigma T^4}{4\pi R^2}=\frac{\sigma\mu^2T^4}{R^2}$

27. $E=\sigma T^4$

Were, σ is Stefan's constant

Given, $E_1=R$, $T_1=273^0C$

= 273 + 273 = 546 K

$T_2=0^0C=273K$

$\therefore \frac{E_1}{E_2}=\frac{T_1^4}{T_2^4}$

$\Rightarrow E_2=\frac{T_2^4}{T_1^4}E_1$

$$\Rightarrow E_2 = \frac{(273)^4}{(546)^4} R$$

$$\therefore E_2 = \frac{R}{16}$$

28. $E = \sigma T^4$

$$\frac{E_1}{E_2} = \left[\frac{T_1}{T_2}\right]^4$$

$$\Rightarrow E_2 = 7\left[\frac{273+727}{273+227}\right]^4 = \left(\frac{1000}{500}\right)^4 \times 7 = 112 cal - cm^{-2} s^{-2}$$

29. $R \propto T^4$

$$\therefore \frac{R'}{R} = \frac{(273+273)^4}{(273+0)^4} = \frac{16 \times (273)^4}{(273)^4}$$

$$\Rightarrow R' = 16R$$

Radiation (Wien's Law, Stefan's Law and Newton's Law of Cooling)

34. $E = \varepsilon \sigma A T^4$

Or $1134 = 1 \times 5.67 \times 10^{-8} \times (0.1)^2 T^4$

T = 1189 K

35. $\frac{dT}{dt} = \frac{A\varepsilon\sigma}{mc}[T^4 - T_0^4]$

When the temperature difference between the body and its surrounding is not very large ie, $T - T_0 = \Delta T$ then $T^4 - T_0^4$ may be approximated as $4T_0^3 \Delta T$

Hence, $\frac{dT}{dt} = \frac{A\varepsilon\sigma}{mc} 4T_0^3 \Delta T$

$$\Rightarrow \frac{dT}{dt} \propto \Delta T$$

37. $\frac{4\pi}{3} r^2 \rho c \left(-\frac{dT}{dt}\right) = \sigma 4\pi r^2 (T^4 - T_0^4)$

$$\therefore\left(-\frac{dT}{dt}\right)=\frac{3\sigma}{\rho rc}(T^4-T_0^4)=H(say)$$

Ratio of rates of all of temperature

$$\frac{H_A}{H_B}=\frac{r_B}{r_A}$$

38. From Stefan's law,

$E \propto T^4$ Or $E=\sigma T^4$

$$\therefore E \propto (727+273)^4$$

$$\Rightarrow E \propto (1000)^4$$

40. Energy received per second by the planet $=\frac{P}{4\pi d^2}(\pi R^2)$

Where, P is power radiated by the sun and R is the radius of the planet

$$\frac{P}{4\pi d^2}(\pi R^2)=\sigma(4\pi R^2)T_0^4$$

$$\Rightarrow T_0^4 \propto d^{-2} \Rightarrow T \propto d^{-1/2}$$

41.

$$\frac{4}{3}\pi r^3=l^3 \Rightarrow \frac{r}{l}=\left(\frac{3}{4\pi}\right)^{\frac{1}{3}}$$

$$R=\frac{d\theta}{dt}\alpha A \Rightarrow \frac{R_1}{R_2}=\frac{A_1}{A_2}$$

$$=\frac{4\pi r^2}{6l^2}=\frac{4\pi}{6}\left(\frac{3}{4\pi}\right)^{2/3}$$

$$=\frac{R_1}{R_2}=\frac{4\pi}{6}\times\frac{3^{2/3}}{4\pi^{2/3}}$$

$$=\frac{(4\pi)^{1/3}}{2}\times 3^{2/3-1}=\frac{1}{2}\left(\frac{4\pi}{3}\right)^{1/3}=\left(\frac{\pi}{6}\right)^{1/3}$$

42. Power radiated from the sun $= (4\pi R^2)\sigma T^4 = P$

Energy received/area/s $= S = \dfrac{P}{4\pi d^2}$

\ $= 4\pi R^2 \sigma \dfrac{T^4}{4\pi d^2} = \sigma T^4 \dfrac{R^2}{d^2} = \dfrac{1}{4}\sigma T^4 \left(\dfrac{2R}{d}\right)^2$

Angle subtended by sun at earth

$\alpha = \dfrac{2T}{d}$

S = constant $\times T^4 \times \alpha^2$

$S \propto T^4$

44. $Q = EAt = e\sigma(T^4 - T_0^4)At$

Where t = time

$T_0 =$ Temperature of surrounding

When $T > T_-$

$Q = e\sigma T^4 At$

$300 = e \times (5.67\times10^{-8})(1000)^4(5.00\times10^{-4})(60)$

e = 0.18

45. $\dfrac{E}{A} = \sigma T^4$

$\therefore E \propto AT^4$ Or $E \propto 4\pi R^2.T^4$

Where A = area of body, T = temperature in Kelvin

Accordingly $R' = 100R$

And $T' = \dfrac{T}{2}$

Hence, energy emitted is

$E' = 4\pi(100R)^2 \left(\dfrac{T}{2}\right)^4$

$$\Rightarrow E' = \left(\frac{100}{4}\right)^2 \times 4\pi R^2 T^4$$

$$E' = \left(\frac{100}{4}\right)^2 \times E$$

$$\therefore \frac{E'}{E} = \left(\frac{100}{4}\right)^2 = 625$$

46. $\lambda_m T = \text{Constant}$

Or $\lambda_m T_1 = \lambda_{m2} T_2$

$$\therefore \lambda_{m2} = \frac{\lambda_{m1} T_1}{T_2} = \frac{14 \times 200}{1000} = 2.8\mu m$$