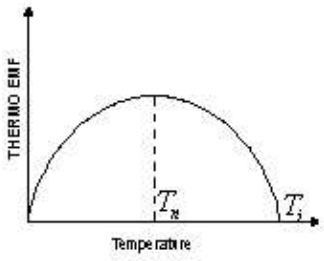
THERMO ELECTRICITY

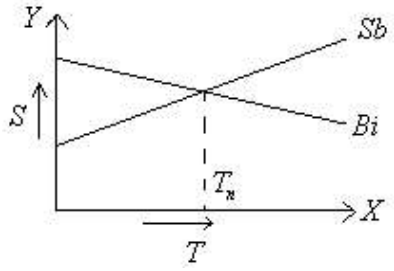
- Thermocouple : Two dissimilar metals joined to form two junctions is called a thermocouple.
- **SEEBECK EFFECT:** An electric current is generated in a circuit containing two dissimilar metals when the two junctions are maintained at different temperatures.
- Density of free electrons is different in different metals. When two different metals are kept in contact, they diffuse from one metal to the other metal. Rate of diffusion depends on temperature. When junctions of thermo couple are at different temperatures, net flow of electrons is established and thermo e.m.f. is developed. This e.m.f is called seeback e.m.f. It depends on nature of metals of thermocouple and temperature difference between the junctions.
- Thermo electric series:- the materials are arranged in a series which are used in a thermocouple. They are Sb, Fe, Zn, Au, Ag, Pt, Rh, Pb, Al, Hg, Cu, Pt, Co, constant an and Bi.
- Materials preceeding Pb are called thermo electrically +ve and those succeeding Pb are called thermoelectrically -ve.
- If any two metals in series form a thermo couple, current flows at cold junction from the metal earlier in the series to the metal later in the series.
- For in given temperature difference, farther the metals selected in series, larger will be the e.m.f.
- The thermo e.m.f. depends on the nature of the material used and on temperature difference of the juncitons.
- Graph drawn between thermo e.m.f. (e) and temperature difference between the junctions is a parabola



- When cold junction is at 0^0C, and hot junction is at t^0C, thermo e.m.f. produced is given by $E = at + bt^2$
- The temperature of hot junction at which thermo e.m.f. is maximum is called neutral temperature for the given pair of metals.
- Neutral temperature is constant for a given thermo couple.
- It is indepedent of cold junction temperature .
- For a given pair of metals $T_n = \frac{-a}{2b}$
- Temperature of hot junction at which thermo e.m.f becomes zero and reversal of thermo e.m.f. takes place is called temperature of inversion.
- Its value depends on the temperature of cold junction
- $T_i = \frac{-a}{b}$
- $T_i - T_n = T_n - T_c$ (T_c = Temperature of cold junction)
- The rate of change of thermo e.m.f. with temperature is called thermo electric power or seebeck coefficient (S)

$$S = \frac{dE}{dt} = \frac{d}{dt}\left(at + bt^2\right) = a + 2bt$$

- Thermo electric diagram or thermo electric power line is a graph drawn between thermo electric power and temperature. It is a straight line.

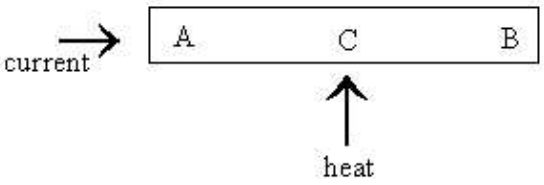


- Substances with positive Seebeck coefficient have +Ve slope and vice versa.
- The point of intersection of the two power lines gives neutral temperature.
- It is drawn for a thermocouple formed with one given metal and the other lead.
- Thermo electric power or Seebeck coefficient is zero at neutral temperature and is maximum at inversion temperature.
- It's unit is Vk^{-1} .Dimensional formula is $\left[ML^2T^{-3}I^{-1}K^{-1}\right]$
- PELTIER EFFECT: When current flows through the junction of two dissimilar metals, heat is absorbed at one junction and heat is evolved at the other junction. This is called Peltier effect.
- Peltier effect is reversible.
- It is inverse of Seebeck effect.
- **PELTIER COEFFICIENT** (π)**:** The amount of heat absorbed or evolved at a junction of two different metals due to flow of 1 coulomb of charge is called Peltier coefficient.

$\pi = \frac{H}{Q}$ Unit of π *is* $\frac{Joule}{Coulomb}$

- $H = \Pi Q$

  $H = \Pi\ i\ t$
- Dimensional formula of Π is $\left[ML^2T^{-3}I^{-1}\right]$
- It depends on nature of metals forming the junction and temperature.
- $\Pi = T.\frac{dE}{dT}$ (T - temperature of cold junctions)
- THOMSON EFFECT: The absorption or evolution of heat when current flows in an unequally heated conductor is called Thomson effect.
- In the case of Cu points of higher temperature will be at higher potential. When current flows from colder to hotter part energy is required and heat is absorbed. This is called positive Thomson effect. other egs:- Ag, Zn, Cd, Cu etc.
- For an Fe rod heated at its mid point, heat is evolved in the part AC and absorbed in part CB.
  This called -Ve Thomson effect. Other egs:- Pt, Ni, Bi, Co etc.



3) For Thomson effect is zero.
- It is reversible effect
- **THOMSON COEFFICIENT** (σ)**:** It is the heat energy absorbed or evolved when Unit current flows for one second between two points of a conductor which differ in temperature by 1K
- Its unit is V/K
- $H = \sigma$ i t dT
- $\sigma = \frac{dV}{dT}$; dV is the potential difference between two points of the conductor with a temperture difference dT.
- Dimensional formula of σ is $\left[ML^2T^{-3}I^{-1}K^{-1}\right]$
- $\sigma = -T\ \frac{d^2E}{dT^2}$

Note:- (1) $\Pi = T.\frac{dE}{dT} = TS$ and

$$\sigma = -T\left(\frac{d^2E}{dT^2}\right) = -T\frac{dS}{dT}$$

- If T_1 and T_2 are the absolute temperatures of cold and hot junctions respectively, the total emf generated in the thermocouple is given by

$$E = \left(\Pi_2 - \Pi_1\right) + \int_{T_1}^{T_2}\left(\sigma_1 - \sigma_2\right)dT$$

Π_1, Π_2 are the peltier coefficient at the junctions

σ_1 and σ_2 are the Thomson coefficients of the metals.

(Seebeck emf = peltier emf + Thomson emf)

Uses of thermo couples

- Thermo electric thermometer is used to measure temperatures more accurately.
- Thermopile is used to detect heat radiations.
- Thermo galvanometer is used to measure A.C. and D.C.
- In thermo galvanometer $\theta\alpha\ i^2$
- **LAW OF INTERMEDIATE METALS:** For the given temperature difference between the junctions, if E_B^A, E_C^B and E_C^A are thermo e.m.f.'s to be developed for thermo couples made with metals (A,B), (B,C) and (A,C), then $E_C^A = E_B^A + E_C^B$

  Eg : $E^{Fe}_{\text{Constantan}} = E^{Fe}_{pt} + E^{pt}_{\text{Constantan}} = E^{Fe}_{pt} - E^{\text{Constantan}}_{pt}$
- LAW OF INTERMEDIATE TEMPERATURES: For the given thermo couple if e_2^1, e_3^2, e_3^1 are the thermo e.m.fs when the junctions are at temperatures (T_1, T_2),(T_2, T_3) and (T_1, T_3) then $e_3^1 = e_2^1 + e_3^2$

  Eg : $e_{100}^0 = e_{40}^0 + e_{100}^{40}$

CONCEPTUAL QUESTIONS

1. For a themocouple, the thermo e.m.f may be
   1. zero 2. positive 3. negative 4. all
2. The large the distance between the elements selected for a thermocouple in the thermo electric series, then for the same difference of temperature, the thermo e.m.f will be
   1. Less 2. More 3. Same 4. Zero
3. Thermo electric thermometer is quick in action because the thermal capacity of the hot junction is
   1. Less 2. More 3. Equal 4. Zero
4. The neutral temperature is 'a' and the inversion temperature is 'b' then the temperature of the cold junction will be

   1. $(-2a-b)$ 2. $\frac{1}{(2a-b)}$ 3. $(2a+b)$ 4. $(2a-b)$
5. The rate of diffusion of electrons in a thermo couple is
   1. Greater at hot junction and less at cold junction
   2. Equal at both junctions
   3. Lesser at hot junction greater at cold junction.
   4. Diffusion of electrons does not takes place.
6. In the construction of a thermo electric thermometer the thermo couple must be selected such that the range of

temperatures to be measured must be
1. Less than cold junction temperature
2. In between cold junction temperature and neutral temperature
3. In between neutral temperature and temperature of inversion.
4. Greater than temperature of inversion.

7. The e.m.f. developed ina thermocouple is given by E = $\alpha t + \frac{1}{2}\beta t^2$ where t is the temperature of hot junction, cold junction being at 0^0C. The thermo electric power of thermo couple is

1. $\alpha + \frac{\beta t}{2}$ 2. $\alpha + \beta t$ 3. $\frac{\alpha + t^2}{2} + \frac{\beta t^3}{6}$ 4. $\frac{\alpha}{2\beta}$

8. The slope of thermo electric curve at any point on it gives corresponding value of
1. thermo emf 2. thermoelectric power
3. neutral temperature 4. none

9. A iron-copper thermo couple is connected to an external battery of e.m.f. E. On doubling the emf of the battery, the heat produced at a junction
1. remains same 2. becomes half
3. is doubled 4. becomes four times

10. Thermo emf produced in a thermo couple depends on the
1. Resistance of the element
2. Lengths of the elements.
3. Temperature of the junction
4. Sizes of the junciton

11. A thermo couple should preferbly not used for measuring temperatures.
1. above neutral temperature.
2. below neutral temperature.
3. above cold junction temperature.
4. above hot junction temperature.

12. A thermo pile is used to measure
1. Ultra violet radiation 2. Infrared radiation
3. X- radiation 4. Small currents

13. Thomson coefficient for lead is
1. positive 2. negative 3. zero 4. none

14. Inversion temperature of a thermo couple depends on
1. Cold junction temperature only
2. hot junction temperature.
3. Nature of the metals only
4. Both on nature of the metals and the cold junction temperature.

15. With increase in the temperature of cold junction of a thermo couple.
1. Both neutral and inversion temperatures are increased
2. Neutral temperature increases and inversion temperature decreases
3. Both neutral and inversion temperature remains the same
4. Neutral temperature remains the same and in version temperature decreases.

16. Thermo couple is based on the principle of
1. Seebeck effect 2. Thomson effect
3. Pelteir effect 4. Joule effect

17. The respective temperature of cold and hot junctions of an Sb- Bi and Fe-Cu thermo couples are same if E_1 and E_2 thermo emf developed in the two cases, then
1. $E_1 = E_2$ 2. $E_1 < E_2$
3. $E_1 > E_2$ 4. Cannot be predicted

18. Thermo electric thermometers are advantageous than ordinary thermometer because
1. They are more sensitive
2. The junctions are very sharp hence small portions of the bodies can also be measured.
3. Thermal capacity of the junctions is small hence rapidly changing temperatures can be measured
4. All the above

19. Thermo electric series helps us to find
1. The direction of thermo electric current in a thermo couple
2. The strength of electron bonds in two different metals.
3. Mass of the substance deposited per 1A of current.
4. to generate more and more heat energy.

20. If the temperature of cold junction of a thermo couple is lowered, its neutral temperature.
1. decreases 2. increases
3. remains same
4. may increase or decrease depending upon the nature of metals in thermocouple.

21. In Iron- copper thermo couple below the inversion temeprature electric current flows at hot junction from
1. Iron to copper 2. Copper to iron
3. No current flows 4.May be in any direction

22. In Sb-Bi themrocuple, beyond the inversion temperature at cold junction, electric current flows from
1. Sb to Bi 2. Bi to Sb
3. No current flows 4. Maybe in any direction

23. Characteristic temperature of thermo couple is
1. Temperature of inversion
2. Neutral temperature
3. Cold junction temperature
4. Temperature of hot junction

24. For thermo couple at neutral temperature
Statement A : Thermo emf is maximum
Statement B : Thermo electric Power is zero.
In these statements
1. A is correct, B is wrong
2. A is wrong, B is correct
3. Both A and B are correct
4. Both A and B are wrong.

25. Unit of Peltier coefficient is
1. JC^{-1} 2. $J\ A^{-1}$ 3. $J\ V^{-1}$ 4. $J\ K^{-1}$

26. Unit of Thomson coefficient is
1. JC^{-1} 2. $J\ A^{-1}$ 3. $J\ V^{-1}$ 4. $V\ K^{-1}$

27. With increase of hot junction temperature in Themocouple, thermo emf
1. always increases with temperature.
2. is always positive
3. can be positive (or) negative
4. first increases with temperature and then decreases with temperature, but never becomes negative.

28. When current passes through the junction at two different metals, evolution or absorption of heat at the junction is known as
1. Seebeck effect 2. Peltier effect
3. Thomson effect 4. Joule effect

29. Consider the two statements A and B
A- Neutral temeperature does not depend on cold junction temperature.
B- Inversion temperature does not depend on cold junction temperature
1. Both A and B are correct
2. A is correct but B is wrong
3. A is wrong but B is correct
4. Both A and B are wrong

KEY

1. 4	2. 2	3. 1	4. 4	5. 1
6. 2	7. 2	8. 2	9. 3	10. 3
11. 1	12. 2	13. 3	14. 4	15. 4
16. 1	17. 3	18. 4	19. 1	20. 3
21. 2	22. 2	23. 2	24. 3	25. 1
26. 4	27. 4	28. 2	29. 2	

LEVEL-1

1. In a given thermo couple, the temperature of cold junction is 0^0C, while the neutral temperature is 270^0 C, the temperature of inversion is
1. 270^0C 2. 540^0C 3. 520^0C 4. 550^0C

2. The neutral temperature of a thermo couple is 500^0C. The inversion temperature if cold junction is at 30^0C is
1. 1030^0C 2. 530^0C 3. 970^0C 4. 1000^0C

3. In a thermo couple the temperature of the cold junction is 15^0C. If the temperature of inversion is 485^0C, the neutral temperature of the thermo couple is
1. 235^0C 2. 985^0C 3. 955^0C 4. 250^0C

4. In a thermo couple, the temperature of cold junction is 25^0C and temperature of inversion is 515^0C. Neutral temperature is
1. 515^0C 2. 490^0C 3. 245^0C 4. 270^0C

5. When the cold junction of thermo couple is at 0^0C neutral temperature is 250^0C. If the cold junciton is at 10^0C, neutral temperature is
1. 250^0C 2. 240^0C 3. 260^0C 4. 255^0C

6. When cold junction is at 0^0C, variation of thermo emf (e) of Fe-Cu thermo couple with temperature of hot junction ''t' is given as $e = 14t - 0.02\,t^2$. Its neutral temperature is
1. 175^0C 2. 1400^0C 3. 700^0C 4. 350^0C

7. One junction of thermo couple is at 0^0C and the other junction is heated. Maximum current in the thermo couple is observed when hot junciton is at 240^0C. The temperature of the hot junction at which the direction of current reverses is
1. 240^0C 2. 480^0C 3. 360^0C 4. 120^0C

8. Neutral temperature of a thermo couple is 250^0C if a = 15 $\mu v/^0$C, the value of b is
1. $-0.03\ \mu v/^o C^2$ 2. $-0.03\ \mu v/^o C$
3. $-0.06\ \mu v/^o C^2$ 4. $-0.06\ \mu v/^o C$

9. thermo emf produced per 1^0C temperature difference between the junciton is 0.005V when cold junciton is at 10^0C, and hot junction is at t^0C, thermo emf produced is 0.5 V,. The value of 't' is
1. 100^0C 2. 90^0C 3. 110^0C 4. 55^0C

10. It π is Peltier coefficient heat evolved at a junction when a current of 10 mA passes for 10 seconds in joules is
1. $\frac{\pi}{10}$ 2. $10\,\pi$ 3. $100\ \pi$ 4. $\frac{1}{10}$

KEY

1. 2	2. 3	3. 1	4. 4	5. 1
6. 4	7. 2	8. 1	9. 3	10.1

LEVEL - II

1. A cell of constant emf of 1.5 V is connected in series with a potentiometer of length 10m through a ressistance of 2980 Ω. When one junction of the thermo couple is in hot oil and the other in melting ice, the balancing point is 450 cm. The resistance of the potentiometer wire per unit length is $2\,\Omega$ / metere. The thermo emf generated will be
1. 0.0045V 2. 0.045V 3. 0.45V 4. 0.00045V

2. The thermo emf of Sb against lead is +4.3 mV and that of Bi against lead is -6.9 mV. when the cold junction is at 0^0C and hot junction at 100^0C. The emf of Sb- Bi thermocouple for the same temperature is
1. -2.6mV 2. 11.2mV 3. +2.6mV 4. 25.67mV

3. The thermo emf in a thermo couple is same when the hot junction temperatures are at 270^0C and 350^0C. The cold junction being maintained at 20^0C. The neutral temperature is
1. 300^0C. 2. 310^0C 3. 320^0C 4. 330^0C

4. Thomson coefficient of a conductor is 10 $\mu V/K$. The two ends of it are kept at 50^0C and 60^0C respectively. Amount of heat absorbed by the conductor when a charge of 10C flows through it is
1. 1000 J 2. 100 J 3. 100 mJ 4. 1 m J

5. In a thermo couple, the thermo emf produced is 3 μV per one degree difference of temperature between two junctions. When the cold junction of such a thermo couple is at 20^0C, the thermo emf is 0.3 mV the temperature of the hot junction is
1. 80^0C 2. 100^0C 3. 120^0C 4. 100 K

6. The cold junction of thermo couple is maintained at $+10^0$C. The emf in the couple reverses its direction when the temperature of hot junction is 510^0C. the temperature at which emf reaches peak value is
1. 250^0C. 2. 260^0C 3. 1020^0C 4. 1000^0C

7. The cold junction of a thermo couple is at 0^0C and the thermo emf (in volts) as a function of the temperature 't' of the hot junction is given by $E = \left[10\times10^{-6}t - \frac{1}{40}\times10^{-6}t^2\right]$.
The neutral temperature and the maximum emf produced are repsectively
1. 200^0C, 1m V 2. 400^0C, 2 mV
3. 100^0C, 1 mV 4. 200^0C, 2 mV

8. A thermo couple is made of iron and constantan thermo emfs of iron and constantan against platinum are 1500 μV and - 3200 μV per 100^{0}C temperature difference between the junctions,then emf developed per 1^{0}C difference of temperature between the junctions made of iron and constantan is

1. 17 μV /^{0}C 2. 4700 μV /^{0}C

3. 47 μV /^{0}C 4. 470 μV /^{0}C

9. Keeping the cold junciton at 0^{0}C when hot junction is at 50^{0}C the thermo emf is 2 mV and when hot junction is at 100^{0}C thermo emf is 3.5 mV. Neutral temperature of that thermocouple (thermo emf varies as e = at + bt^2)

1. 75^{0}C 2. 25^{0}C 3. 50^{0}C 4. 225^{0}C

10. For a thermo couple a = $4.5\times10^{-5} V/^0 C$, b = $-2\times10^{-7} V/^0 C^2$, thermo electric power at 100^{0}C is $\left(E = at + bt^2\right)$

1. 25 $\mu V/^0 C$ 2. zero

3. 5 $\mu V/^0 C$ 4. 45 $\mu V/^0 C$

11. When the cold junction is at 0^{0}C and hot junction is below the temperature of inversion, emfs developed by Sb - Pb and Pb - Bi thermo couples are 31 μV and 69 μV per degree centigrade respectively. Thermo emf developed by Sb - Bi thermocouple per ^{0}C is

1. 100 μV /^{0}c 2. 38 μV /^{0}c

3. 31 μV /^{0}c 4. 69 μV /^{0}c

12. Keeping the cold junction at 0^{0}C, thermo emf due to a thermo couple is same whether hot junction is at 200^{0}C or 360^{0}C. Neutral Temperature is

1. 275^{0}C 2. 260^{0}C 3. 300^{0}C 4. 280^{0}C

13. When cold junction is at 0^{0}C and hot junction is at 100^{0}C, thermo emf's developed by Fe - Pb and Pb - Bi thermocouples are 650 μV and 450 μV respectively. thermo emf developed for Fe - Bi thermocouple per 1^{0}C temperature difference is

1. 1100 μV 2. 550 μV

3. 11 μV 4. 200 μV

KEY

1. 1	2. 2	3. 2	4. 4	5. 3
6. 1	7. 1	8. 3	9. 4	10. 3
11.1	12.4	13. 3		

HINTS

1. thermo emf generated = Potential gradiend x Balancing length
2. Use laws of intermediate metals
3. $\theta_n = \frac{\theta_1 + \theta_2}{2}$
4. σ q $\Delta t = Q$
5. thermo emf α Temp. defference
6. $T_i - T_n = T_n - T_c$
7. Find neutral temperature and substitute the same in the given equation.
8. Use law of Intermediate metals
10. $P = \frac{dE}{dt}$
11. $E_{Bi}^{Sb} = E_{Pg}^{Sb} + E_{Bi}^{Pb}$
12. $\theta_n = \frac{\theta_1 + \theta_2}{2}$

NEW MODEL QUESTIONS

I. Consider the following two statements in each question and identify the correct answer.

1. (A) Free elecltron density in a metal depends on temperature
(B) Free electron density is different in different metals. Seebeck effect is caused.
1) Both A and B are true
2) Both A and B are false
3) A is true but B is false
4) A is false B is true

2. (A) Cu-Fe thermocouple produces more thermo emf than Bi-Sb couple.
(B) Thermo electric effect is used to measure heat radiation.
1) Both A and B are true
2) Both A and B are false
3) A is true but B is false
4) A is false B is true

3. (A) neutral temperature is independent of temperature of cold junction
(B) Peltier effect is the converse of Seebeck effect.
1) Both A and B are true
2) Both A and B are false
3) A is true but B is false
4) A is false B is true

4. (A) Thermo galvanometer is suitable to measure DC only
(B) Thermopile can measure temperature differences only of the order $10^{-1}\ ^0C$.

1) Both A and B are true
2) Both A and B are false
3) A is true but B is false
4) A is false B is true

5. (A) Thermo emf depends on nature of metals and temperature of junctions.
(B) By a thermo electric thermometer we can measure temperature of the sun.
1) Both A and B are true
2) Both A and B are false
3) A is true but B is false
4) A is false B is true

KEY

1. 1 2) 4 3) 1 4) 2 5) 3

II In each of the following questions a statement of assertion
(A) is given followed by a corresponding statement of reason
(R). Mark the correct answer as
1) Both A and B are true and R is correct explanation of A
2) Both A and B are true and R is not correct explanationof A
3) A is true R is false 4) A is false R is true.
1) - 1 2) - 4 3) - 2 4) - 3

II In each of the following questions a statement

4.1) **Assertion (A):** Thomson effect is due to diffusion of free electrons in an unequally heated metal
Reason (R): Thomson effect takes place throughout the metal.

2) **Assertion (A):** Rapidly changing temperatures can be measured by thermocouples.
Reason (R): The thermal capacity of the junction of a thermocouple is very small.

3) **Assertion (A):** Thermo galvanometer can be used to measure AC as well as DC
Reason (R): Heat produced in the resistance is independent of direction of current

4) **Assertion (A):** When two dissimilar metals are joined across the junction and maintained at different temperature a potential difference is developed.
Reason (R): Electrons drift from one metal to the other.

5) **Assertion (A):** A thermocouple cannot be used for measuring temperature beyond neutral temperature
Reason (R): Neutral temperature is independent of temperature of cold junction

6. **Assertion (A):** In the thermo electric series Cu appears earlier than Fe.
Reason (R): At cold junction of Cu - Fe thermocouple thermo electric current flows from Fe to Cu.

7. **Assertion (A):** Joules heating effect is irreversible.
Reason (R): Seebeck effect and Peltier effect are reversible

KEY

1) 2 2) 1 3) 1 4) 3 5) 2
6) 4 7) 2

III. Match the following:

1) **List-I** **List - II**
a) Thermo emf e) Calorie
b) Peltier coefficient f) Volt
c) Thomson coefficient g) Joule/Coulomb
d) Joule heat h) Volt/K

1) $a-f, b-g, c-h, d-e$
2) $a-g, b-f, c-e, d-h$
3) $a-f, b-g, c-e, d-h$
4) $a-f, b-h, c-g, d-e$

2) List-I List - II
a) neutral temperature e) - a/b
b) temperature of inver sion f) - a/2b
c) Maximum thermo emf g) $-a^2/4b$
d) Thermo electric power h) a + 2 bt

1) $a-f, b-e, c-h, d-g$
2) $a-f, b-e, c-g, d-h$
3) $a-f, b-g, c-e, d-h$
4) $a-e, b-f, c-g, d-h$

3) **List - I** **List - II**
a) Peltier effect e) irreversible
b) Joule heating effect f) reversible
c) Thomson effect in Pb g) negative
d) Thomson effect for metal like Fe h) zero.

1) $a-e; b-f; c-g; d-h$
2) $a-f; b-e; c-h; d-g$
3) $a-f; b-h; c-e; d-g$
4) $a-e; b-h; c-f; d-g$

4) **List - I** **List - II**
a) Thermo pile e) J/C
b) Duddel galvano- meter f) depend on cold junc- tion temperature
c) Peltier coefficient g) heat radiation
d) inversion h) rapidly varying AC

1) $a-f; b-e; c-h; d-g$
2) $a-g; b-h; c-e; d-f$
3) $a-h; b-g; c-f; d-e$
4) $a-f; b-e; c-g; d-h$

KEY

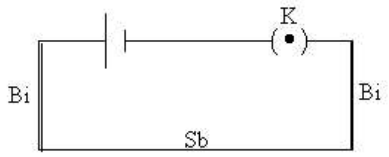
(1) 1 (2) 2 (3) 2 (4) 2

IV Multi Correct Type Questions

1. Which of the following is/are wrong
   a) Seebeck effect is irreversible
   b) Thomson effect is localised at the junction
   c) Joule heating effect is independent of the direction of flow of current in a conductor
   1) a and b are wrong 2) a and c are wrong
   3) b and c are wrong 4) all are wrong

2. A graph is drawn between the temperature difference between the junctions (x-axis) and thermo emf on y-axis. Then
   a) it is a parabola b) it is hyperbola
   c) it's slope at any point gives thermoelectric power
   d) it's slope at any point on it gives Seebeck coefficient
   1) a and c are true 2) b and d are true
   3) a, c and d are true 4) b,c and d are true

3. A battery is connected to Sb - Bi thermocouple as shown in figure. The junctions A and B are at same temperature. When the key k is open. When k is closed due to Peltier effect
   a) heat is absorbed at A
   b) heat is absorbed at B
   c) temperature of B < temperature of A
   d) temperature of A < temperature of B



   1) a and c are true 2) b and d are true
   2) b and c are true 4) a and d are true

KEY

1) 2 2) 3 3) 4

V. Order Arranging Type Questions:

1. The arrangement of some of the metals forming thermoelectric series is Sb, Fe, Zn, Ag, Mo, Cr, Sn, Pb, Hg, Mn, Cu, Co, Ni, Bi. Arrange the following thermocouples in the ascending order of producing thermo emf at a particular constant temperature
   a) Fe - CO b) Sb - Bi
   c) Ag - Mn d) Zn - Cu
   1) b, a, d, c 2) c,d, a, b
   3) d, c, b, a 4) b, c, d, a

2) The thermo emf's of four thermocouples are as shown. Identify the correct order in which their neutral temperatures increase.

Thermocouple	emf (μV)
P	$100t - t^2/3$
Q	$10t - t^2/20$
R	$60t - \frac{1}{4}t^2$
S	$250t - \frac{1}{2}t^2$

   1) Q, R, P, S 2) P, Q, R, S
   3) S, R, P, Q 4) S, P, R, Q

KEY

(1) 2 (2) 1