Solution of the Theoretical Problem of the 5 th IJSO

Problem I

I-1. F/m^2 kg / (m s^2)

I-2. 13.6 ? 76.0 cm = 1033.6 cm = 10.336 m
Or 10.3 m

I-3. 1 atm = 13.6 ? 10^3 kg/m^3 ? 0.76 m ? 9.80 m/ s^2 = 1.013 ? 10^5 kg/m·s^2 = 1.013 ? 10^5 Pa
Or 1.01 ? 10^5 kg/m·s^2 = 1.01 ? 10^5 Pa

I-4. When the blood pressure is 120 mmHg (systolic pressure), the blood can go up to 10.3 m /760 mmHg ? 120 mmHg = 162.6 cm
162.6 cm ? g = 42 cm ? g_{eff} => g_{eff} ? 3.87 g
g_{eff} = g + a. Therefore a = 2.87 g = 28.1 m/s^2

I-5. By the continuity equation $A_1 v_1 = A_2 v_2$, Area of the aorta is A_1 =p r_{aorta}^2, and total cross-sectional area of the arteries are A_2 = 32pr_{artery}^2.
$v_2 = v_1$? A_1/A_2 = 0.25 m/s ? (p(0.012 m)^2)/(32p(0.002 m)^2) = 0.28 m/s

I-6. The volume flow rate ?V/? t must stay the same, r_1^4 ? $P_1 = r_2^4$? P_2 .
? P_2 /? $P_1 = r_1^4/r_2^4 = 1/(0.9)^4$? 1.52. Therefore the blood pressure increases 52%.

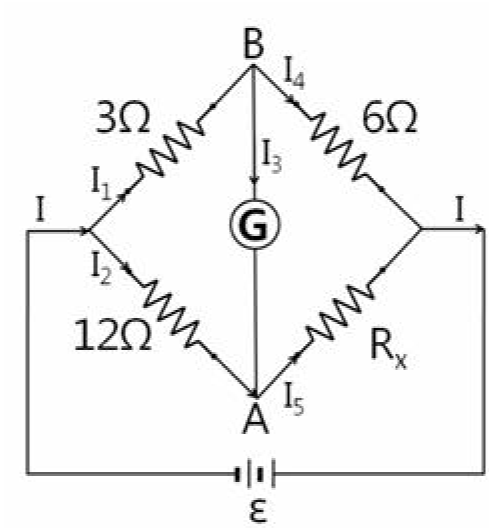
I-7(A) – 4, (B) – 1, (C) – 2, (D) – 3, (E) – 5

I-8, 0 V

I-9 80 ? R_x = 120 ? 60 , R_x = 9 0

I-10. 0V

I-11. Total resistance is 6 Ω, total current is 1 A. The emf of the battery is 6 V



By the Kirchhoff's rule,

$I = I_1 + I_2 = I_4 + I_5$, $I_1 = I_3 + I_4$, $I_5 = I_2 + I_3$

$12 I_2 + 9 I_5 = -e$, $3 I_1 + 6 I_4 = -e$,

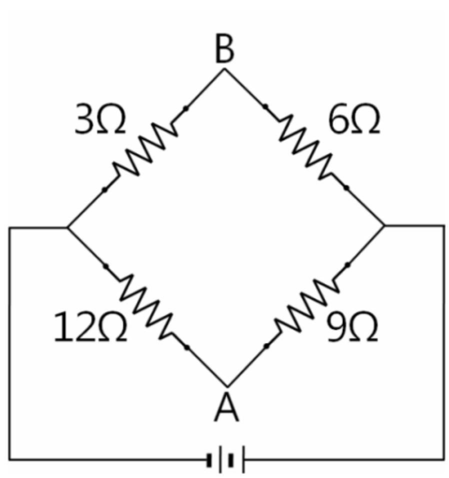
$3 I_1 - 12 I_2 = 0$, $9 I_5 - 6 I_4 = 0$

$I_3 = -0.2$ A

$I_2 = -0.2$ A, $I_1 = -0.8$ A, $I_4 = -0.6$ A, $I_5 = -0.4$ A

$e = -6$ V

I-12.



Total resistance is 6.3 Ω, and the total current is 6/6.3 A ? 0.953 A

The current through 3 Ω is 2/3 A ≅ 0.667 A, and the current through 12 Ω is 2/7 A ? 0.286 A

The potential drop by 3 Ω is 2 V, and the potential drop by 12 Ω is 24/7 V ? 3.43 V

The potential difference is 1.43 V, and A is higher than B.

Problem II

II-1. Total energy required to travel 100 km = 13.0 L × 0.70 kg/L × 44000 kJ/kg = 400000 kJ

Amount (L) of liquid propane needed to travel the same distance (100 km)

= 400000 kJ / 46000 (kJ/kg) / 0.50(kg/L) = 17 L

? distance that can travel with 1 L of liquid propane = 100/17 = 5.9 km/L

II-2. Number of moles for methane in 1 mL of LNG = 1 × 0.42 × 1000/16 = 26 mmol

Assuming the ideal gas, V = nRT/p

V = 26 × 0.082 × 298/1.0 = 640 mL

II-3. Assuming the ideal gas, the density of the gas $\rho = \frac{W}{V} = \frac{PM}{RT}$,

where M is molar mass.

Average molar mass of the LPG mixture = 0.6 × 44 + 0.4 × 58 = 49.6 g/mol

At 25 ? and 1 atm, the density of the LPG mixture

$= \frac{1 \times 49.6}{0.082 \times 298} = 2.0$ g/L = 2.0 kg/m^3

II-4. $C_8H_{18}(l) + 25/2\ O_2(g)$? $8\ CO_2(g) + 9\ H_2O(g)$

or

$2\ C_8H_{18}(l) + 25\ O_2(g)$? $16\ CO_2(g) + 18\ H_2O(g)$

II-5. For each fuel, compare the amount of CO_2 produced when 1 kJ of energy is obtained.

Since all C's are converted into CO_2 in the combustion reaction of fuels, the number of moles of CO_2 produced with 1 mole of fuel is equal to the number of C atoms in a single fuel molecule:

1 mole of octane(C_8H_{18}) ? 8 mole of CO_2 produced

1 mole of methane(CH_4) ? 1 mole of CO_2 produced

Combustion of 1 mole of octane:

energy produced = 44000 × 114/1000 = 5016 kJ mass CO_2 = 8 × 44 = 352 g

g CO_2/kJ = 352/5016 = 0.070 g/kJ

Combustion of 1 mole of methane:

energy produced = 54000 × 16/1000 = 864 kJ

mass CO_2 = 1 × 44 = 44 g

g CO_2/kJ = 44/864 = 0.051 g/kJ

II-6. Combustion energy of 1 L of gasoline = 1 × 0.70 × 44000 = 30800 kJ

Energy that the solar cell with the area of 1 m^2 can produce for 1 hour

= 1KW × 3600s × 0.2 = 720 kJ

Area needed for the solar cell = 30800/720 = 43 m^2

Problem III

III-1) Yes

Critical night length is given by interrupting a long night length, which results in two short night.

III-2) No

The length of light is not critical for flowering.

III-3) Yes

Since critical night length is given for flowering, interruption of light length doesn't matter.

III-4) No

Effect of red light is cancelled by a flash of far-red light. P_{fr} isoform, which was converted by red light, is going back to P_r isoform by far-red light.

III-5) Yes

R-F-R is identical condition as R alone. Thus, a flash of red light interrupting a long night can make a critical short night length to fulfill flowering condition for long-day plant.

III-6) P_{fr}

Since sun light is rich in red light that can convert P_r isoform to P_{fr} isoform, P_{fr} isoform becomes dominant.

III-7) P_r

Continuous darkness is the condition for conversion of P_{fr} isoform to P_r isoform.

III-8) Yes

The signaling molecules, which are transported to the grafted bud meristems, are able to cue the buds to develop as flower.

III-9) No

The light condition given here is not for the short-day plant to flower and then signaling molecules is absent.

III-10) No

The signaling molecules are too big to pass through the coverglass so that they are not present to cue flowering in the bud meristem area.