

## Physics For Life Sciences 2: Exam 2 Solutions

### Section A

1. A	5. D	9. C	13. B	17. C	21. A
2. D	6. A	10. C	14. B	18. A	22. D
3. D	7. D	11. D	15. B	19. C	23. C
4. B	8. B	12. A	16. B	20. D	

### Section B

**Question 1** Two electric charges are brought together until they are 1.0 m apart, causing the electric force to increase by a factor of 4. What was their initial separation? [14]

Answer: Since

$$|\vec{\mathbf{F}}| = \frac{k|q_1||q_2|}{r^2},$$

this implies that, for this case where the electric charges are the same,

$$\frac{|\vec{\mathbf{F}}_f|}{|\vec{\mathbf{F}}_i|} = \left(\frac{r_i}{r_f}\right)^2 \Rightarrow r_i = \sqrt{\frac{|\vec{\mathbf{F}}_f|}{|\vec{\mathbf{F}}_i|}} r_f.$$

The subscripts “i” and “f” stand for initial and final, respectively. It is given that

$$\frac{|\vec{\mathbf{F}}_f|}{|\vec{\mathbf{F}}_i|} = 4, \quad r_f = 1.0 \text{ m},$$

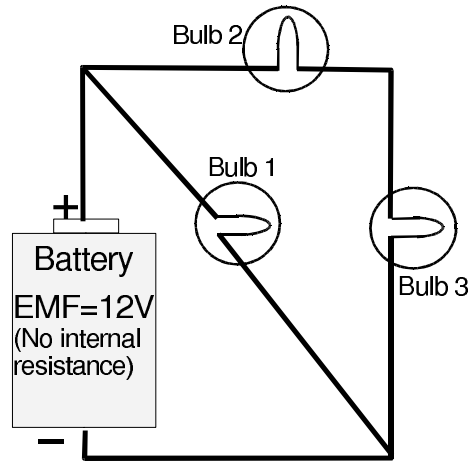
Hence

$$r_i = (\sqrt{4}) \cdot (1.0 \text{ m}) = 2.0 \text{ m}.$$

## Question 2.

Consider the circuit on the right. Each of the three bulbs has a resistance of  $3\Omega$ . Assume the battery has an electromotive force of  $12\text{ V}$  and no internal resistance.

- What is the current through each bulb? [10]
- What is the voltage across each bulb? [10]
- What is the total power (energy per unit time) supplied by the battery? [6]



All three bulbs each have resistance of  $3\Omega$ .

## Answers:

- Bulb 1:  $I_1 = V/R = (12\text{ V})/3\Omega = 4\text{ A}$ .  
Bulbs 2 and 3: The effective resistance of the two bulbs in series is  $R_{\text{eff}} = 3\Omega + 3\Omega = 6\Omega$ . Therefore, the current through both bulbs 2 and 3 is  $I_2 = I_3 = V/R_{\text{eff}} = (12\text{ V})/6\Omega = 2\text{ A}$ .
- Bulb 1: The voltage is the same as across the battery:  $V_1 = 12\text{ V}$ .  
Bulb 2:  $V_2 = I_2 R_2 = (2\text{ A}) \cdot (3\Omega) = 6\text{ V}$ .  
Bulb 3:  $V_3 = I_3 R_3 = (2\text{ A}) \cdot (3\Omega) = 6\text{ V}$ .
- The current through the battery is the sum of the currents through the two branches of the circuit through the light bulbs; *i.e.*,  $I_{\text{battery}} = 4\text{ A} + 2\text{ A} = 6\text{ A}$ . Therefore the power supplied by the battery is  $P = VI = (12\text{ V}) \cdot (6\text{ A}) = 72\text{ W}$ .

Alternatively, bulb 1 and bulbs 2 & 3 together are resistors of resistance  $3\Omega$  and  $6\Omega$  in parallel. Therefore, the effective resistance of the bulbs, as seen by the battery, is  $(3\Omega) \cdot (6\Omega)/(3\Omega + 6\Omega) = 2\Omega$ . Therefore, the power supplied by the battery is  $P = V^2/R = (12\text{ V})^2/2\Omega = 72\text{ W}$ .