National 5 Physics

Solutions to Electricity & Energy exam questions

1. (a)

$$I = \frac{P}{V}$$ (1)

$$= \frac{60}{230}$$ (1)

$$= 0 \cdot 26 \text{ A}$$ (1) [number **and** unit must be correct] 3

(b) (i)

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$ (1)

$$\frac{1}{R_T} = \frac{1}{46} + \frac{1}{92}$$ (1)

$$R_T = 30 \cdot 67\ \Omega$$ (1) [number **and** unit must be correct] 3

(ii)

$$P = \frac{V^2}{R}$$ (1)

$$= \frac{230^2}{30 \cdot 67}$$ (1)

3

$$= 1725 \text{ W}$$ (1) [number **and** unit must be correct]

[or calculate individual power of each heating element and add together]

(iii) S3 (only) 1

(iii) Greatest value of resistance 1
OR
lowest current
OR
lowest power

2. (a)

$$I = \frac{V}{R}$$ (1)

$$= \frac{12}{64000}$$

$$= 1{\cdot}875 \times 10^{-4} \text{ (A)}$$ (1) for correct current

THEN

[no mark for reuse of Ohm's Law]

$$V = IR$$

$$= 1{\cdot}875 \times 10^{-4} \times 4000$$

$$= 0{\cdot}75 \text{ V}$$

(1) [number **and** unit must be correct] 3

(b) Transistor (switch) (1) 1

(c)

- R of LDR increases (1)
- V across LDR increases (1)
- (above 0·7V) Transistor switches ON (1)
- Relay coil is energised (1)
  (which closes the relay switch and activates the motor) 4

3. (a) $c = 4180$ (J Kg^{-1} C^{-1}) (1) full marks only possible when correct value from datasheet is used.

$E_h = c\,m\,\Delta T$ (1)

$= 4180 \times 1.6 \times 80$ (1) 4

$= 535040$ J (1) [number **and** unit must be correct]

(b) (i) Eh = mL (1)

$Eh = 0.9 \times 22.6 \times 10^5$ (1) for correct L value from datasheet

(1) both substitutions correct

$Eh = 2.034 \times 10^6$ J. (1) [number **and** unit must be correct] 4

(ii) $P = \frac{E}{t}$ (1)

$$2000 = \frac{2.034 \times 10^6}{t}$$ (1)

t = 1017 s (1) [number **and** unit must be correct] 3

4. $E_p = m\,g\,h$ (1)

$= 25 \times 9.8 \times 1.2$ (1)

$= 290$ J (1) [number **and** unit must be correct] 3

5	(a)	(i)	(33-21) = 12 °C	(1)	[number **and** unit must be correct]	1
		(ii)	(120,000-12,000) = 108,000 J	(1)	[number **and** unit must be correct]	1
		(iii)	$E_h = cm\Delta T$	(1)		
			108,000 = c x 2.0 x 12	(1)		
			c = 4,500 J kg^{-1} $°C^{-1}$	(1)	[number **and** unit must be correct]	3
	(b)	(i)	Any **two** of the following;			
			Measured value of Eh too large	(1)		
			OR			
			ΔT too small	(1)		
			OR			
			Heat lost to surroundings (or similar)	(1)		
			OR			
			water not evenly heated (or similar)	(1)		2
		(ii)	Insulate beaker			
			OR			
			Put lid on beaker			
			OR			
			Stir water			
			OR			
			Fully immerse heater			1
	(c)		E = P t	(1)		
			108,000 = P x (5 x 60)	(1)		
			P = 360 W	(1)	[number **and** unit must be correct]	3

6 (a)

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \quad (1)$$

$$= \frac{1}{4} + \frac{1}{2} \quad (1)$$

$$\therefore R_T = 1{\cdot}3\ \Omega \quad (1)$$

[number **and** unit must be correct]

3

(b) $R_T = R_1 + R_2$ (1)

$= 1{\cdot}3 + 6$ (1)

$= 7{\cdot}3\ \Omega$ (1) [number **and** unit must be correct] 3

(c) (Voltage across 2 Ω resistor = Voltage across 4 Ω resistor)

$V = IR$ (1)

$= 0{\cdot}1 \times 4$ (or $0{\cdot}2 \times 2$) (1)

$= 0{\cdot}4$ V (1) [number **and** unit must be correct]

3

7	(a)	dc – electrons flow (or current flows) around a circuit in one direction only	(1)	
		ac – electrons' (or current) direction changes/reverses after a set time	(1)	2

8. (a) To reduce current in LED 1

OR

To reduce voltage across LED

(b) $V = 6 - 2 = 4$ V (1)

$V = IR$ (1)

$4 = 0.1 \times R$ (1)

$R = 40\ \Omega$ (1) [number **and** unit must be correct] 4

(c) $P = I^2R$ OR $P = V^2/R$ (1)

$= (0{\cdot}1)^2 \times 40$ $= \frac{4^2}{40}$ (1)

$= 0{\cdot}4$ W $= 0{\cdot}4$ W (1) [number **and** unit must be correct] 3

OR

$P = IV$ (1)

$= 0{\cdot}1 \times 4$ (1)

$= 0{\cdot}4$ W (1) [number **and** unit must be correct]

9. D

10. E

11. B

12. A

13. E

14. A

15. (a) (i) P = I V (1)

36 = I x 12 (1)

I = 3 A (1) [number **and** unit must be correct] 3

(ii) 48 = 12 + 12 + V_R

V_R = 24 V (1) [number **and** unit must be correct] 1

(iii) V = I R (1)

24 = 3 x R (1)

R = 8 Ω (1) [number **and** unit must be correct] 3

(b) (i)

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$$ (1)

$$\frac{1}{R_T} = \frac{1}{6} + \frac{1}{4} + \frac{1}{4}$$ (1)

$$\frac{1}{R_T} = 0 \cdot 17 + 0 \cdot 25 + 0 \cdot 25$$

$$R_T = 1 \cdot 5\ \Omega$$ (1) [number **and** unit must be correct]

3

(ii) A. The reading decreases/gets smaller/reduces (1) 1

B The resistance increases (so the current decreases) (1) 1

16. (a)

Use Ohm's Law twice.
Once to calculate the current, then once to find V_R.

V = I R (1)
0.36 = I x 2000
I = 0.00018 (A)

V = I R [no mark for using equation again]

= 0.00018 x 4800 (1) for **both** substitutions

= 8.64 V (1) [number **and** unit must be correct] 3

(b)

$$P = \frac{V^2}{R}$$ (1)

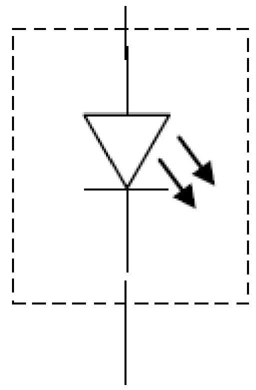
$$3 = \frac{V^2}{48}$$ (1)

$$V^2 = 144$$

$$V = 12\ V$$ (1) [number **and** unit must be correct]

3

17. (a)



1

(b) Protect the LED OR prevent damage to the LED

OR

limits the current 1

OR

reduces voltage across LED

(c)

$V_R = 6 - 1 \cdot 2 = 4 \cdot 8\ \text{V}$ (1)

$V = IR$ (1)

$4 \cdot 8 = 15 \times 10 - 3 \times R$ (1)

$R = 320\ \Omega$ (1) [number **and** unit must be correct]

4

18.

$$P = I^2R \quad (1)$$

$$= (200 \times 10^{-3})^2 \times 20 \quad (1)$$

$$= 0 \cdot 8\ \text{W} \quad (1)$$ [number **and** unit must be correct] 3

19. (a)

$$E = Pt \quad (1)$$
$$= 1500 \times 35 \quad (1)$$
$$= 52\ 500\ J \quad (1)$$

[number **and** unit must be correct] 3

(b)

$$E = cm\Delta T \quad (1)$$
$$52\,500 = 902 \times m \times (200 - 24) \quad (1)$$
$$m = 0.33\,kg \quad (1)$$

[number **and** unit must be correct] 3

(c) Heat is 1

- Lost OR
- Radiated OR
- escapes OR

from the sole plate

20. C

21. D

22. D

23. E

24. (a) (i) $E_p = m g h$ (1)

$E_p = 0.50 \times 9.8 \times 19.3$ (1)

$E_p = 95$ J (1) 3

(ii) $E_c = c m \Delta T$ (1) [number **and** unit must be correct]

$95 = 386 \times 0.50 \times \Delta T$ (1)

$\Delta T = 0.5$ °C (1) [number **and** unit must be correct] 3

(iii) Less than. (1)

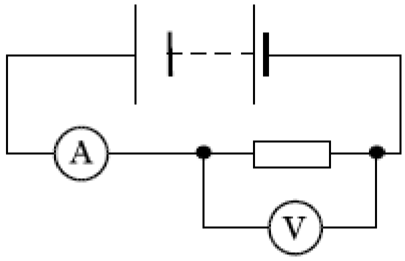
Some heat is lost to surroundings/ or equivalent. (1) 2

(b) $E_h = mL$ (1)

$E_h = 0 \cdot 5 \times (2 \cdot 05 \times 10^5)$ (1)

$E_h = 1 \cdot 025 \times 10^5$ J (1) [number **and** unit must be correct] 3

25. (a)



Ammeter in series (1)
Voltmeter in parallel with resistor (1)
Battery (not cell) symbol (1)

3

(b)

$V = IR$ (1)

$5.7 = 0.60 \times R$ (1)

$R = 9.5\,\Omega$ (1) [number **and** unit must be correct] 3

(c) Power rating of resistor = 3 W 1

Power developed in resistor is

P = IV (1)

P = 0.6 × 5.7 (1)

P = 3.42 W (1)

The power rating of the resistor is too low for these current & voltage values. (1) 4

(d) No, the student is not correct. (1)

In parallel the voltage across each resistor is still the same (1)
OR
6V across each resistor so power is the same (1) 2

26 (a) MOSFET (1) 1

(b) Voltage decreases (1) 1

(c) (i)

$$V_s = V_T + V_{RV}$$

$$12 = 2 \cdot 4 + V_{RV}$$

$V_{RV} = 9 \cdot 6\ V$ (1) [number **and** unit must be correct]

(ii) $\frac{V_T}{V_{RV}} = \frac{R_T}{R_V}$ (1)

$\frac{2 \cdot 4}{9 \cdot 6} = \frac{5600}{R_V}$ (1)

$R_V = 22400$ V (1) [number **and** unit must be correct] 3

(d) The lamp stays on. (1)

When temperature decreases, R_T increases (1)

Increase in R_T will increase voltage across the thermistor (V_T). (1) 3

(so MOSFET does not switch off)

27. (a) Parallel (1) 1

(b) $P = I V$ (1)

$300 = I \times 230$ (1)

$I = 1.3$ A (1) [number **and** unit must be correct]

OR

$P = I V$ (1)

$900 = I \times 230$

$I = 3.9$ A

Current in one mat= $3.9 \div 3$ (1)

$I = 1.3$A (1) [number **and** unit must be correct] 3

(c) P total = 3 x 300W = 900W

$P = V^2 / R$ (1)

$900 = 230^2 / R$ (1)

$R = 59\ \Omega$ (1) [number **and** unit must be correct]

OR

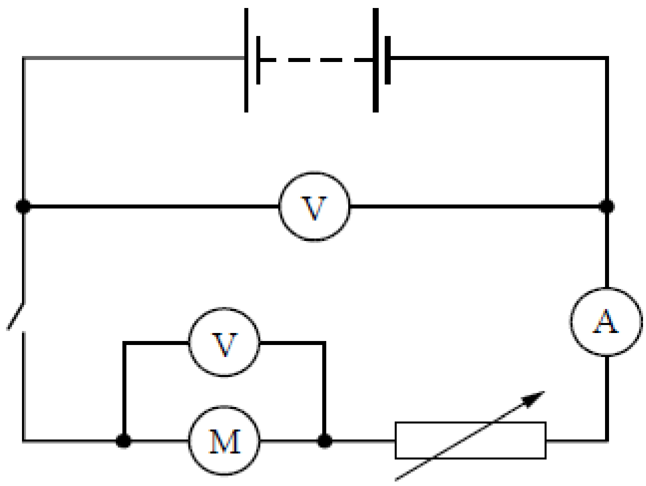
$I_{total} = 3 \times 1.3 = 3.9$ A

$P = I^2 R$ (1)

$900 = 3.9^2 \times R$ (1)

$R = 59\ \Omega$ (1) [number **and** unit must be correct] 3

28. (a) 1



(b) Vr = Vs - Vmotor

= 24 - 18

= 6 (V) (1)

Vr = I R (1)
6 = I x 2.1 (1)
I = 2.9 A (1) [number **and** unit must be correct] 4

(c) Q = I x t (1)

= 3.2 x (10 x 60 x 60) (1)

= 115 200 C (1) [number **and** unit must be correct] 3

29. $t = 1/250 = 0{\cdot}004$(s) (1)

$E = P\,t$ (1)

$60 \times 10^{-3} = P \times 0.004$ (1)

$P = 15$ W (1) [number **and** unit must be correct] 4

OR

$E_{Total} = 250 \times 60 \times 10^{-3}$ (J) (1)

$E = P\,t$ (1)

$15 = P \times 1$ (1)

$P = 15$ W (1) [number **and** unit must be correct]

30. (a) Transistor 1

(b)

- (As temp increases,) input voltage to transistor increases (1)
- (above 0·7V) switching transistor on (1)
- Current in the (relay) coil produces magnetic field to close switch. (1)

3

(c) $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$ (1)

$\frac{1}{R_t} = \frac{1}{16} + \frac{1}{16}$ (1)

3

$R_t = 8\ \Omega$ (1) [number **and** unit must be correct]

31. (a) $E_h = cm\Delta T$ (1)

$= 4320 \times 82 \times 125$ (1)

$= 44\ 280\ 000$ J (1) [number **and** unit must be correct] 3

(b) Eh = 60% of the heat energy is used

$E_h = 44\ 280\ 000 \times 0.6 = 26\ 568\ 000$ J (1)

$E_h = mL$ (1)

$26\ 568\ 000 = m \times (3.42 \times 10^5)$ (1)

$m = 77.7$ kg (1) [number **and** unit must be correct]

32. (a) Lamp A (1)

It has the lowest resistance/highest current/greatest power (1)

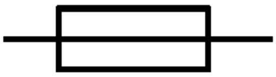
2

(b) $P = V^2/R$ (1)

$= 24^2/2\cdot$ (1)

$= 230$ W (1) [number **and** unit must be correct] 3

(c)



1

(d) (i) 12 V 1

(ii) $1/R_p = 1/R_1 + 1/R_2$ (1)

$= 1/8 + 1/24$ (1)

$R_p = 6\ \Omega$ (1) [number **and** unit must be correct] 3

(e) The motor speed will reduce (1)

The (combined) resistance (of the circuit) is now higher (1)
OR
current is lower (1)
OR
Voltage across motor is less (1)
OR
Motor has less power (1) 2

33. (a) (i) transistor 1

(ii) To act as a switch 1

(b) Resistance of LDR reduces, so voltage across LDR reduces (1)
Voltage across variable resistor/R increases (1)
When voltage across variable resistor/R reaches 0·7 V transistor switches buzzer on. (1) 3

(c) 80 units: resistance of LDR = 2500 (Ω)
Total resistance = 2500 + 570
= 3070 (Ω) (1)

I = V/R (1)

= 5/3070 (1)

= $1{\cdot}63 \times 10^{-3}$ A or 1·63 mA (1) [number and unit must be correct] 4

(d) To set the light level at which the transistor will switch on
OR
To set the level at which the buzzer will sound 1

34. A

35. A

36. C

37. B

38. C

39. C

40. $P = \frac{F}{A}$ (1)

$1 \cdot 01 \times 10^5 = \frac{262}{A}$ (1)

$A = 2 \cdot 59 \times 10^{-3}$ m^2 (1) [number and unit must be correct] 3

41. B

42. C

43. A

44. B

45. (a) (i) $P = \frac{F}{A}$ (1)

$$4 \cdot 6 \times 10^5 = \frac{F}{3 \times 10^{-2}} \text{ (1)}$$

$F = 13\,800$ N (1) [number and unit must be correct]

(ii) $P_1V_1 = P_2V_2$ (1)

$$(4 \cdot 6 \times 10^5) \times (1 \cdot 6 \times 10^{-3}) = (1 \cdot 0 \times 10^5) \times V_2 \text{ (1)}$$

$V_2 = 7 \cdot 36 \times 10^{-3}$ m^3 (1) [number and unit must be correct]

46. When the volume of a gas decreases,

- the distance to the walls of the container decreases (1)
-
- gas particles collide with the walls more often/frequently (1)
-
- the increased collision rate increases the force on the walls, so pressure is increased. (1) 3

47. When the temperature of a gas is increased,

- the gas particles gain kinetic energy (1)
-
- and collide with the walls more often/frequently AND each collision exerts a greater force on the container walls (1)
- the increased force results in increased gas pressure. (1) 3

48. D

48. (a) $P_1V_1 = P_2V_2$ (1)

$(750 \times 10^3)\times(8 \cdot 0 \times 10^{-2}) = (125 \times 10^3)\times V_2$ (1)

$V_2 = 0 \cdot 48\ m^3$ (1) [number and unit must be correct]

(b) Volume of cylinder = $8 \cdot 0 \times 10^{-2}\ m^3$

total volume of gas available to fill balloons
= 0.48 – 0.08 = 0.4 m^3 (1)

number of balloons filled = 0.4 ÷ 0.02 (1)

= 20 balloons (1)