Marks

6. An energy-saving system is installed in a new office block. If the natural light level in an office is high enough, the lights turn off automatically. The control circuit is shown in Figure Q6.

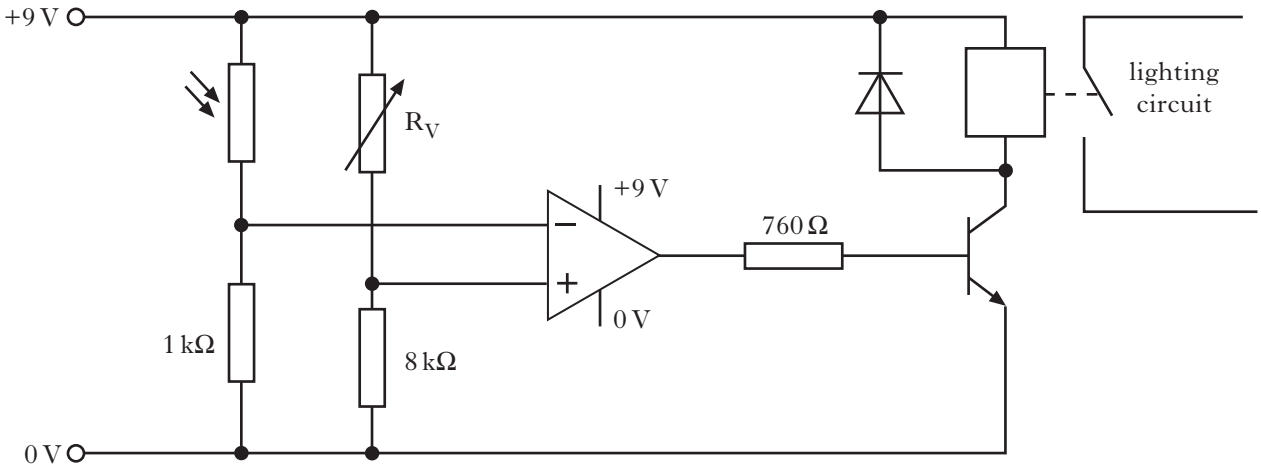

Figure Q6

(*a*) Calculate the value of R_V so that the light circuit switches off at 650 lux. **2**

(*b*) Calculate the base current when the op-amp output is high. **2**

The resistance of the relay is 15 Ω.

(*c*) (i) Calculate the collector current when the transistor saturates. **1**

(ii) Calculate the minimum current gain of the transistor. **1**

(iii) State which of the transistors shown in the table below is most suitable for this circuit. **1**

(7)

Device	V_{CE}(max) (V)	I_c(max) mA	h_{FE}
2N3704	30	600	100
BC108	25	200	100
BC142	60	1000	20
BC182	50	100	120
BC548b	30	100	220
BFY51	30	1000	40

[Turn over

9. (continued)

When the ignition is turned on the system performs a check of the sensors. If a fault is detected a warning lamp is illuminated. The op-amp-based system shown in Figure Q9(*c*) performs this check.

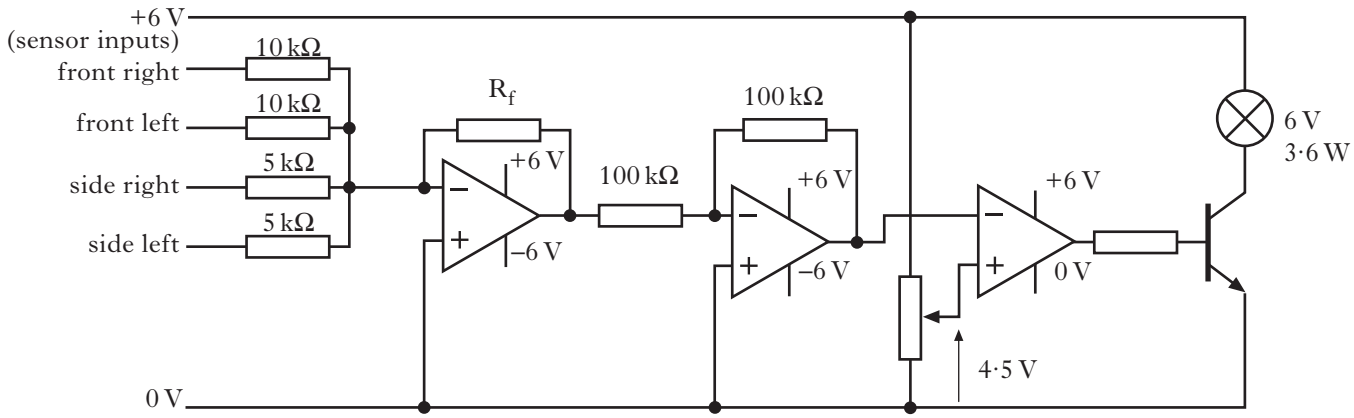

Figure Q9(*c*)

When the car is stationary a front sensor should have an output voltage of 1·2 V and a side sensor should have an output of 0·6 V.

(*e*) Calculate an appropriate value for R_f so that the warning lamp will light if any of the sensors produce a test voltage output below the correct value. **2**

A bipolar transistor-based driver circuit controls the lamp.

When a fault exists, the base current is 15·5 mA and the voltage across the lamp is 6 V.

(*f*) Calculate the minimum current gain for the driver circuit. **1**

(20)