M1.(a) It is not actually connected to 0V ✓
OR
Operational amplifier has a very large open loop gain

The voltage between V_+ and V_- inputs has to be zero [or tiny] otherwise will saturate✓

2

(b) V_{OUT} = -270K / 22K x V_{IN} = -12.3 V_{IN}
OR

V_{IN} = 50 x 0.01 = 0.5 V ✓

V_{OUT} = -12.3 x 0.5 = -6.1V ✓

2

(c) At 122 °C V_{OUT} = 122 x 0.01 x 12.3 = 15.0 V ✓
so any higher temp will give no further increase in V_{OUT} ✓ WTTE
OR
Max V_{IN} = 15.0 / 12.3 = 1.22 V ✓

Max input temperature = 1.22 / 0.01 = 122 °C ✓

2

(d) Level is fixed by controlling the pd at the + input)
OR
Turns off at higher temperature if V at + terminal higher✓
Output of the circuit is determined by R_f / R_i(V2 – V1) ✓

When V1 = V2 the output changes from + to - (causing heater to switch off) ✓

3

[9]

M2.(a) (i) negative feedback: part or all of the output is fed back to the input 180° out of phase **(1)**

achieved through R_f **(1)**

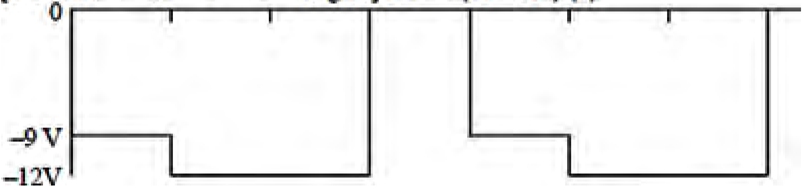
(ii) greater stability
less distortion any two **(1) (1)**

increased bandwidth
gain predictable

4

(b)

[use of $V_{out} = -R_f\left(\frac{V_1}{R_1}+\frac{V_2}{R_2}\right)$ to give] $V_{out} = -(V_1 + 2V_2)$ **(1)**



negative values **(1)**
correct 9 V and 12 V **(1)**
saturation **(1)**
repeated **(1)**

max 4
[8]

M3.(a) $I_a = \frac{1.2}{6(k\Omega)}$ = 0.2 mA **(1)**

I_b = 0.3 mA and I_c = 0.6mA **(1)**
correct direction of current shown **(1)**

(b) current through R_f = 1.1(mA) gives $V_{out} = 1.1 \times 10^{-3} \times 10 \times 10^3$ = 11V **(1)**
negative value **(1)**

(c) V_{out} (22 V)> supply voltage [or saturated] **(1)**
V_{out} = (–)15V **(1)**

[6]