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) inverting (amplifier) **(1)**

1

(b) use of $V_{out} = (-)\frac{R_f}{R_i} \times V_{in}$ **(1)**

$= (-)\frac{120}{30} \times 0.5 = -2.0$ V **(1)**

2

(c) (i) $V_{peak\ (input)} = 2.0 \times \sqrt{2} = 2.8(3)$ V **(1)**

(ii) input trace (A): sinusoidal with T = 20 ms **(1)**
and peak = 2.8 V **(1)**

for output voltage, $V_{peak\ (out)} = (-)\frac{120}{30} \times 2.8(3) = (\pm)11.3$ (V) **(1)**

(allow C.E. for value of $V_{peak\ (input)}$ from (i)

trace B: inversion w.r.t. trace A **(1)**
same period as trace A **(1)**
flat region (saturates) at ± 5 V **(1)**

max 6

[9]