15 The photograph below was taken by the James Webb Space Telescope (JWST) and shows a group of galaxies that formed shortly after the big bang, about 13×10^9 years ago.

(Source: © NASA, ESA, CSA, STScI)

(a) (i) Derive the equation $T = 1/H_0$ where T is the age of the universe.

(1)

(ii) State one assumption made in your derivation.

(1)

(iii) The parsec (pc) is a unit used for astronomical distances. 1 pc is 3.1×10^{16} m.

The accepted range for the Hubble constant H_0 is (60–80) km s^{-1} Mpc^{-1}.

Deduce whether the observation by the JWST leads to a value of H_0 within the accepted range.

1 year = 3.16×10^7 s

(3)

(b) The light from one of the galaxies, called Maisie, has a redshift z of 14.
The wavelength of light from Maisie detected at the telescope is 4.0×10^{-6} m and lies within the infrared section of the electromagnetic spectrum.

(i) Calculate the wavelength of light emitted by Maisie.

(3)

Wavelength emitted = ...

(ii) Explain why the light emitted by Maisie arrives at the telescope as infrared.

(2)

(c) One of the infrared detectors on the JWST is made from material with a work function of 0.30 eV.

Deduce whether this detector can detect the light from Maisie.

(4)

(Total for Question 15 = 14 marks)