

### Question 1

- a. +2 for  $de/df = 0$   
+3 for correct execution/answer
- b. +2 for setting up integral with correct limits  
+3 for correct execution/answer

### Question 2 -

- a. +1 for reasonable attempt  
+1 for ability to explain logic (ie could I follow what you were doing?)  
+1 for correct equation  
+1 for evaluation of  $d\theta$  as  $r \rightarrow \pi R$
- b. +2 for correct answer
- c. +1 for reasonable attempt  
+1 for ability to explain logic (ie could I follow what you were doing?)  
+1 for correct equation  
+1 for correct expansion as  $r \ll R$

### Question 3

- a. +2 for reasonable estimation of number of protons ( $10^{26}$  ish)  
+2 for getting net charge on rock  $(N_{\text{electrons}} - N_{\text{protons}})e^-$   
+3 for Coulomb's law and reasonable answer ( $10^7$  ish N)
- b. +2 for thoughts