

- I. 1d ; 2b; 3c; 4a; 5d; 6d
- II.  $E_n = -13.6/n^2$  (eV)
- a)  $E(\text{photon}) = E_4 - E_2 = 13.6(1/4 - 1/16)$  eV = 2.6 eV
- b)  $E(\text{photon}) = h f$   
 $f = E(\text{photon})/h = 2.6 \text{ eV} / 4.1 \times 10^{-15} \text{ eV} \cdot \text{sec} = 6.3 \times 10^{14} \text{ sec}^{-1}$
- III. a) probability for one day to have precipitation  
 $P = 11/38 = 0.29$  or 29%
- b) prob for no precipitation in one day =  $(1-P) = 0.71$  or 71%  
 So for 3 days have  $(1-P)^3 = (0.71)^3 = 0.36$
- c) prob for ONLY ONCE in 3 days?  
 For (yes-no-no) it would be  $P \times (1-P)^2$ . Same for (no-yes-no) and (no-no-yes).  
 So total prob for ONLY ONCE is  
 $3 \times P \times (1-P)^2 = 3 \times 0.29 \times (0.71)^2 = 0.44$
- IV.  $\Delta x \Delta p \geq h/4\pi$   
 So  $\Delta p(\text{min}) = h/(4\pi \Delta x) = 6.6 \times 10^{-34} \text{ J} \cdot \text{sec} / (4\pi \times 10^{-7} \text{ m})$   
 $= 5.3 \times 10^{-28} \text{ Kg} \cdot \text{m}/\text{sec}$   
 (or units of  $\text{J} \cdot \text{sec}/\text{m}$  since  $1 \text{ J} = 1 \text{ Kg} \cdot \text{m}^2/\text{sec}^2$ )

V. For the essay the grade depends on evidence that you have read the play as demonstrated by your use of appropriate citations to the text. Each essay choice should refer to a section (or sections) of the play in which one or more of the characters address the issue. Along with those references a broader interpretation is needed to make sense out of the character's positions on the questions. Furthermore, an indication that you have some understanding of the physics concepts that are involved is essential.

For example, in addressing question (a) you would indicate there is a section where B & H talk about this issue. You would have to refer to that discussion. But then what are their positions on how QM differs from Classical Mechanics and Special Relativity in the role of the human observer? What kind of metaphoric leap are the characters making in their assertions about the role of humans? Does QM apply to their discussion or is it a poorly chosen metaphor? In what sense is the observer a crucial part of QM? There are many approaches you could take to this essay question that would indicate you read the material, had some thoughtful responses to it and that you understand something about the interpretation of QM.