Practice Test Questions 5A
Band Theory

1. Define the following terms as they apply to band theory.

(a) valence band

(b) conduction band

(c) insulator

(d) extrinsic semiconductor

(e) n-type semiconductor

2. *Please answer (a) and (b) side by side so that the relative scales are obvious.*

(a) Draw the band structure of potassium

(b) Draw the band structure of silicon.

(c) One of these two elements is an insulator. Which one? Explain your choice.

3. A small amount of phosphorus is added to a sample of silicon to improve its ability to conduct electricity.

(a) Is this an example of a *p*-type semiconductor or an *n*-type semiconductor?

(b) Explain how the addition of phosphorus increases conductivity.

4. In insulators and semi-conductors, what is the significance of the conduction and valence bands?

5. Elemental germanium has the same diamond structure as elemental silicon. A small amount of gallium is added to a sample of germanium to improve its ability to conduct electricity.

(a) Is this an example of a *p*-type semiconductor or an *n*-type semiconductor?

(b) Explain how the addition of gallium increases conductivity.

(c) The band gap in germanium at 325 K (i.e. a hot summer day in the sun) is 62.7 kJ/mol. Calculate the *longest* wavelength of light that can be absorbed by a photovoltaic solar cell based on a *P/N* junction at germanium. (Note: at typical doping levels up to 10^{18} atoms/cm^3, the dopants do not affect the size of the band gap significantly; these effects can be ignored in this problem.)

6. An exciting new technology being developed for graphic displays involves the use of semiconductors which absorb different amounts of energy depending on particle size. This energy is then re-emitted as photons of light. Different particle sizes give different colours.

Use band theory to explain why the larger particles produce colours toward the red end of the visible spectrum while smaller particles produce colours toward the violet end.

Your answer must include:

- the relationship between colour and energy of light
- what happens when energy is absorbed by the semiconductor
- what happens when photons are emitted by the semiconductor
- the effect of particle size on the above two processes

You may consider each particle to be a single molecule and assume that all particles contain the same elements in the same ratio. For the purposes of this question, it does not matter whether the semiconductor is intrinsic or extrinsic.

7. A diode is composed of an n-type and a p-type semiconductor connected to each other. Explain how this device restricts the flow of electrons in one direction.

Your answer should include a diagram.