Question 1

What is a necessary condition for perfect secrecy?

Claude Shannon proved that a cipher has perfect secrecy if and only if there are as many possible keys as possible plaintexts, so every key is equally likely.

This means the key has to be random and as long as the message... which means that this is not practical for most real-word use cases

See page 133 of the Security Engineering text.

Question 2

How did Robert Hooke use a one-way function in 1678?

He published an anagram of a message and revealed its meaning two years later.

This allowed him to establish priority for his idea (Hooke’s Law for a spring) without disclosing it at the time.

See page 137 of the Security Engineering text.

Question 3

What are the three properties of hash functions listed in the text?

1. They are one-way functions
   - Given x, it is easy to compute h(x)
     but difficult to find x when given h(x)

2. The function does not give any information about any part of the input.

3. It is hard to find collisions
   - A collision is when you can find two messages M1, M2 where M1 ≠ M2 but h(M1) = h(M2)

See section 5.3.1 (Random Functions – Hash Functions), 5.3.1.1 (Properties) Page 141

Question 4

What is meant by a trapdoor one-way permutation?

“This is a computation which anyone can perform, but which can be reversed only by someone who knows a trapdoor such as a secret key.”

Public key cryptography is an example of this

- If I encrypt a message with my private key, k: C = E_k(M)
- Nobody can decrypt it without the “trapdoor”, knowledge of my public key, K: M = D_K(C)

See page 147 of the text.
Question 5
How does confusion differ from diffusion in an SP network?

- **Confusion**
  - Confusion uses the key (known only to trusted parties) to modify the plaintext values (switch ones and zeros).
  - Every bit of ciphertext depends on various bits of the key. You cannot find a connection between a bit of the key and a bit of the ciphertext.

- **Diffusion**
  - The plaintext information is spread throughout the cipher so that a change in one bit of plaintext will affect many other bits.
  - If you change a bit in the plaintext, approximately half of the bits in the ciphertext will change.

Question 6
What does an s-box do in a symmetric block cipher?

- It is a substitution box – it substitutes one pattern of bits with another.
- Think of it as a lookup table:
  - Example:
    - Input = 1101
    - Output = 1010

See page 5.4.1, SP Networks, p. 149 in the Security Engineering text.

6. Discussion: s-boxes

- **Block ciphers**
  - Encrypt a chunk of data at a time (rather than a byte at a time).
  - Versus stream ciphers, which encrypt one byte at a time.
  - Essentially all symmetric block ciphers use SP Networks.

- **General goal: Confusion and Diffusion**
  - Confusion = key hides the relationship between any bit of the plaintext input and any corresponding bit of the ciphertext output.
  - Diffusion = spread plaintext data throughout ciphertext block.

- **SP Networks: substitution and permutation**
  - Used in implementing block ciphers.
  - S-box = lookup table that maps a set of bits onto another set.
  - Some bits of the key may select which s-box to use.
  - ... or some bits of the key might be used as input to the s-box.

6. Discussion: s-boxes

- Encryption involves multiple rounds.
  - The output of one set of s-box operations is used as input to the next round.

- A simple 16-bit, 2-round SP-network from the text (p. 151):

![SP-network diagram](image-url)