A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

17.1 Encryption, Encryption Protocols and Digital Certificates

Name: _____ Class: _____ Date: _____ **Total: 35 marks**

KEY WORDS digital certificate 数字证书 • encryption 加密 • digital signature 数字签名 • symmetric encryption 对称加密 • asymmetric encryption 非对称加密

Objective

Build the skills to answer exam questions on **encryption** 加密 — symmetric and asymmetric keys, TLS, and digital certificates.

You must be able to:

- explain how **encryption** works and compare **symmetric** and **asymmetric**
- describe the **hybrid** approach and outline **TLS**
- explain a **digital certificate** and how it is checked

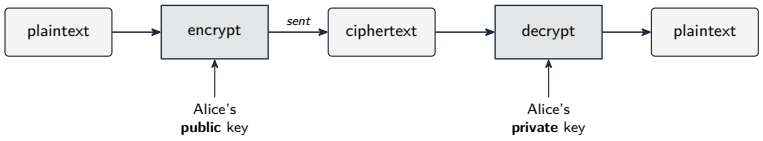
1 Worked examples

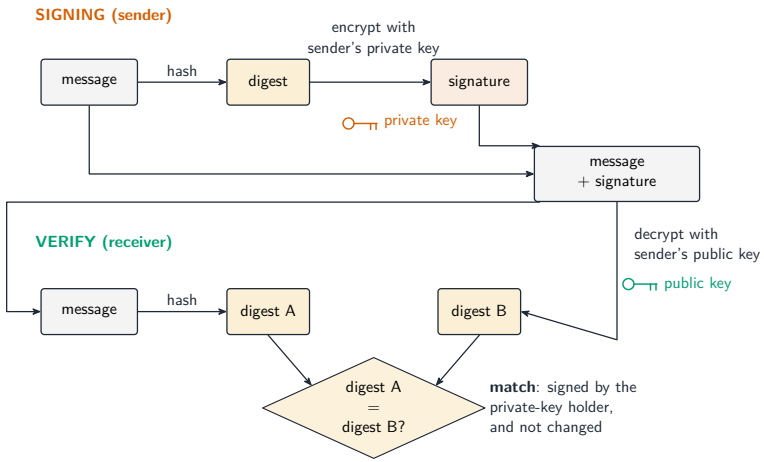
Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

Encryption basics

Encryption turns readable **plaintext** into unreadable **ciphertext** using a **key**; only the right key reverses it (**decryption**).

- **Symmetric** — the **same** key encrypts and decrypts. Fast (good for bulk data), but how do you **share the key** safely?
- **Asymmetric (public-key)** — a **pair** of keys. Encrypt with the recipient's **public** key; only their **private** key can decrypt:





A digital signature authenticates a message

Hybrid (how HTTPS really works)

Asymmetric is **slow**, so it is used only to exchange a fresh **session key**, then fast **symmetric** encryption carries the data. A **TLS** handshake: the server sends its **digital certificate** (with its public key); the client checks it; both agree a **session key**; all later traffic is symmetric.

Digital certificate

A **digital certificate** binds an **identity** to a **public key**, signed by a trusted **Certificate Authority (CA)**. The browser checks the **expiry**, that the **name matches**, and that it is **signed by a trusted CA**.

Digital signature

A **digital signature** 数字签名 proves a message came from the real sender (**authenticity**) and was not changed (**integrity**):

1. the sender **hashes** the message to a fixed-length **digest**;
2. they **encrypt the digest with their *private* key** — this is the signature, sent with the message;
3. the receiver decrypts the signature with the sender's **public key** to recover the digest, and **re-hashes** the received message;
4. if the two digests **match**, the message is genuine and unchanged; if not, it was altered.

2 Practice

Now apply the methods above.

2.1 Define **plaintext** and **ciphertext**. [2]

2.2 State the key difference between **symmetric** and **asymmetric** encryption. [1]

2.3 State the main **problem** with symmetric encryption. [1]

2.4 State what a **digital certificate** binds together. [1]

3 Exam-style questions

3.1 Bob wants to send Alice a secret message using asymmetric encryption. Which of Alice's keys does Bob use to **encrypt**, and which does Alice use to **decrypt**? Explain why this is secure. [3]

3.2 Explain why real systems (like HTTPS) use a **hybrid** approach combining asymmetric and symmetric encryption. [3]

3.3 State **two** things that **TLS** provides. [2]

3.4 State **one** check a browser makes on a **digital certificate**. [1]

3.5 Explain how a **digital signature** lets the receiver check that a message has **not been changed** during transmission. [3]

3.6 An online shop uses **asymmetric** encryption and digital certificates to protect its customers.

(a) **Describe** how a pair of asymmetric keys is used so that a customer can send card details that only the shop can read. [3]

(b) **Explain** why the shop must never publish its **private** key, and what it does publish instead. [2]

(c) The shop obtains a **digital certificate** from a certificate authority. **Describe** what the certificate contains and how it proves the shop's identity. [4]

(d) **Describe** the purpose of the **SSL/TLS** protocol, and **state** where it sits relative to the other protocols in use. [3]

(e) **Outline** the steps of the TLS handshake that take place before any card details are sent. [4]

(f) **Explain** why the session then switches to **symmetric** encryption. [2]