3.1.1 Primary memory: RAM, ROM and their types

Name: _____ Class: _____ Date: _____ **Total: 44 marks**

KEY WORDS primary memory • volatile • cache • refreshed • firmware

Objective

Learn to answer exam questions on **primary memory**: what RAM and ROM are for, how **SRAM** and **DRAM** differ, and how the three types of programmable ROM differ. Sheet 3.1 introduced these ideas; this sheet takes them to exam level. Storage devices come on sheet 3.1.2.

You must be able to:

- explain why a computer needs primary memory, and say what is held in **RAM** and what is held in **ROM**
- explain the differences between RAM and ROM, and give their uses in a range of devices
- explain the differences between **Static RAM (SRAM)** and **Dynamic RAM (DRAM)**, and justify which one a device should use
- explain the difference between **PROM**, **EPROM** and **EEPROM**

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

■ RAM and ROM

Primary memory is the memory the processor reads **directly**. A program on the hard disk is copied into it before it can run.

RAM
volatile — lost at power off
read *and* write
holds running programs & data

ROM
non-volatile — kept at power off
read-only
holds start-up instructions

	RAM	ROM
full name	Random Access Memory	Read Only Memory
power off	contents **lost** (**volatile**)	contents **kept** (**non-volatile**)
read / write	read **and** write	read only, in normal use
holds	programs and data **in use now**	**start-up** (bootstrap) instructions
and	operating system parts in use	**firmware**

Volatile memory loses its contents without power; **non-volatile** memory keeps them. **Firmware** is the fixed program that controls a device's hardware.

"RAM or ROM in this device?" Does the item **change** while the device runs? Yes → RAM. No, and it must be there at switch-on → ROM.

A microwave oven: the program for the cooking cycles → **ROM**; the cooking time the user typed in, and the time left → **RAM**.

■ SRAM and DRAM

	SRAM (static)	DRAM (dynamic)
a bit is stored in	a **flip-flop**	a transistor and a **capacitor**
refresh	**not needed**	**needed**: the charge leaks away
access speed	**faster**	slower
bits per chip	fewer	**more**
cost per bit	higher	**lower**
power used	lower	higher (it must refresh)
used for	**cache**	**main memory**

A **flip-flop** is a circuit of several transistors that holds its bit as long as there is power. The charge on a **capacitor** leaks, so every bit of DRAM is read and rewritten many times a second: it is **refreshed**.

"Which one, and why?" A full-mark answer has a **property** and **why it suits the use**:

- *cache*: SRAM is **faster**, and cache must pass data to the processor with as little delay as possible. Cache is small, so the high cost does not matter.
- *main memory*: DRAM is **cheaper and denser**, and main memory must hold many GB.

■ **PROM, EPROM and EEPROM**

- All three are programmed **after** manufacture; ordinary ROM is written in the factory.
- They differ in **whether**, and **how**, they can be erased. UV light is ultraviolet light.

type	can it be erased?	how it is erased	is the chip removed?
PROM	**no**: written **once**	cannot be erased	not applicable
EPROM	yes, many times	**UV light**, the **whole** chip	**yes**, taken out
EEPROM	yes, many times	**electrically**, in parts	**no**, erased in place

A smart TV gets a firmware update over the internet. Nobody opens the TV → the firmware is in **EEPROM**, the only type that is rewritten electrically, **in place**.

Past-paper practice: complete sheets 3.1.1 and 3.1.2 before attempting past-paper set 3.1.2.

2 Practice

Now use the methods above. The first questions need one idea each.

2.1 Complete each sentence with **RAM** or **ROM**. [4]

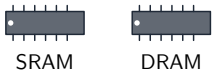
(a) The start-up instructions of a computer are stored in .....

(b) The document you are typing now is held in .....

(c) The contents of ..... are lost when the power is switched off.

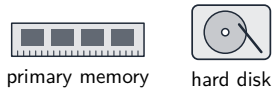
(d) In normal use the processor can read from, but cannot write to, ...

2.2 Tick (✓) **one** box in each row to show whether the statement describes SRAM or DRAM. [5]



Statement	SRAM	DRAM
It must be refreshed.		
It stores each bit in a flip-flop.		
It has the faster access time.		
It stores more bits on one chip.		
It is used for cache memory.		

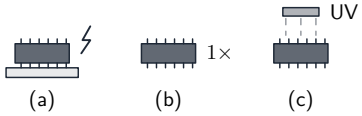
2.3 Explain why a computer needs primary memory as well as a hard disk. [2]



2.4 Explain why DRAM must be refreshed. [2]

2.5 State the type of programmable ROM described in each case. [3]

(a) It is erased by an electrical signal, without being removed from the device.

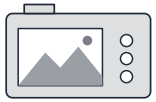


(b) It can be programmed once only.

(c) It must be taken out of the device and put under ultraviolet light to be erased.

2.6 A digital camera takes a photo and shows it on its screen. State whether each item is held in RAM or in ROM, and give a reason. [4]

(a) the program that controls the camera



(b) the photo that has just been taken and is being shown on the screen

3 Exam-style questions

3.1 A laptop computer has 16 GB of DRAM and 8 MB of SRAM.

(a) Give **two** reasons why DRAM, not SRAM, is used for the 16 GB of main memory. [2]

16 GB DRAM
8 MB SRAM

(b) Explain why SRAM is used for the cache memory. [2]

(c) The user opens a large spreadsheet file. **Describe** what happens to the file so that the processor can work on it. [2]

3.2 A company makes a heart-rate monitor that a runner wears on the wrist. The company will improve the monitor's program several times after the monitors are sold.

(a) **State** the most suitable type of programmable ROM for the monitor's program. **Justify** your choice. [3]

(b) Give **one** reason why PROM is **not** suitable for this monitor. [1]

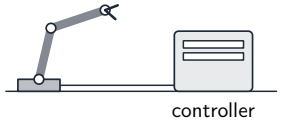
(c) State **one** item of data that the monitor holds in RAM, and explain why RAM is suitable for it. [2]

3.3 A student says: *"ROM is memory that can never be changed."*

Explain why this statement is **not** correct for every type of ROM. [2]

3.4 A factory buys a new robot arm. The robot's controller has ROM, SRAM and DRAM.

(a) **Describe** the contents of the ROM when the robot is delivered. [2]



(b) While the robot works, its controller runs one large program and stores thousands of sensor readings. A small part of the program is used again and again at very high speed.

Explain how the controller uses its DRAM **and** its SRAM in this situation. [4]

(c) The factory's power fails for ten seconds. **State** what happens to the contents of the ROM, the SRAM and the DRAM. [2]

(d) The maker wants to correct an error in the robot's start-up program without sending an engineer to open the controller. **Explain** which type of programmable ROM makes this possible. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

(a) start-up instructions never change and must survive power off → **ROM**

(b) a document in use changes all the time → **RAM**

(c) the volatile memory is **RAM**

(d) read but not write in normal use → **ROM**

2.2

- refresh → the capacitor in **DRAM** leaks
- flip-flop → **SRAM**
- faster access → **SRAM**
- more bits per chip → **DRAM**, because each bit needs fewer parts
- cache → **SRAM**

Statement	SRAM	DRAM
It must be refreshed.		✓
It stores each bit in a flip-flop.	✓	
It has the faster access time.	✓	
It stores more bits on one chip.		✓
It is used for cache memory.	✓	

2.3

- the processor can only read instructions and data **directly** from primary memory
- so a program and its data are copied from the hard disk into RAM to be run; primary memory is also much faster to access

2.4

- DRAM stores each bit as a charge on a **capacitor**
- the charge **leaks away**, so the bit would be lost unless it is read and rewritten regularly

2.5

(a) electrical erase, in the device → **EEPROM**

(b) programmed once only → **PROM**

(c) removed and erased with UV light → **EPROM**

2.6

(a) the control program never changes and must be there when the camera is switched on

- so it is in **ROM**

(b) the photo on the screen is data in use now, and it changes with every new photo

- so it is in **RAM**

3.1

(a) any **two** of:

- DRAM costs less per bit, so 16 GB is affordable
- DRAM has a higher density, so 16 GB fits in a small space
- main memory does not need the very fastest access, so the slower speed is acceptable

(b) SRAM has a **faster access time** and needs no refresh

- cache must pass frequently used instructions and data to the processor with as little delay as possible; it is small, so the high cost per bit is acceptable

(c) the file, or the part of it in use, is **copied** from secondary storage into **RAM**

- because the processor can only work directly on data in primary memory

3.2

(a) **EEPROM**

- it can be erased and rewritten with an electrical signal while it **stays inside** the monitor
- so the new version of the program can be loaded by the user, without opening the monitor or removing the chip

(b) PROM can be programmed only **once**, so the program could never be improved

(c) for example the current heart rate, or the time run so far

- this data changes all the time, so it must be in memory that can be written to; it does not need to be kept when the monitor is off

3.3

- EPROM and EEPROM **can** be erased and programmed again (with UV light, or electrically)
- ROM means only that the contents are not changed **in normal use** and are kept without power; PROM can also be written once after manufacture

3.4

(a) the **start-up (bootstrap) program** that runs when the controller is switched on

- the **firmware**: the fixed program or routines that control the robot's hardware

(b) the large program and the sensor readings are held in **DRAM**

- because DRAM is cheap and dense, so a large memory is possible
- the small part that is used again and again is copied into **SRAM** (used as cache)

- because SRAM has a faster access time, so these instructions reach the processor with less delay

(c) the contents of the SRAM and the DRAM are **lost**, because both are volatile

- the contents of the ROM are **kept**, because it is non-volatile

(d) **EEPROM**

- it can be erased and reprogrammed electrically while it is still in the controller, so the corrected program can be sent to the robot and installed in place