**Research assignment – Electron microscope (Answers)**

1. An **electron microscope** is a microscope that uses a beam of accelerated [electrons](https://en.wikipedia.org/wiki/Electron) as a source of illumination. (1) The electron microscope has a higher [resolving power](https://en.wikipedia.org/wiki/Angular_resolution) than a [light microscope](https://en.wikipedia.org/wiki/Optical_microscope) and can reveal the structure of smaller objects. (1)
2. **1931 Ernst Ruska and Max Knoll built the first TEM**

1938 First scanning transmission electron microscope (M. von Ardenne)

1939 First commercial TEM by Siemens (Ruska, von Borries)

**In 1931 the German engineers Ernst Ruska and Maximillion Knoll succeeded in magnifying an electron image.**This was, in retrospect, the moment of the invention of the electron microscope but the **first prototype was actually built by Ruska in 1933 and was capable of resolving to 50 nm.**  Although it was primitive and not really fit for practical use, Ruska was recognised some 50 years later by the award of a Nobel Prize. **The first commercially available electron microscope was built in England by Metropolitan Vickers for Imperial College, London, and was called the EM1,** though it never surpassed the resolution of a good optical microscope.

c)

1. The light source is replaced by a beam of very fast moving electrons. (1)
2. The specimen usually has to be specially prepared and held inside a vacuum chamber from which the air has been pumped out (because electrons do not travel very far in air). (1)
3. The lenses are replaced by a series of coil-shaped [electromagnets](http://www.explainthatstuff.com/magnetism.html) through which the electron beam travels. In an electron microscope, the coils bend the electron beams. (1)
4. The image is formed as a photograph (called an **electron micrograph**) or as an image on a [TV screen](http://www.explainthatstuff.com/television.html). (1)

d) Label- (1), ruler / pencil-(1), diagram with title (2)

## e) Some electron microscopes can magnify specimens up to 2 million times (1)

## Scanning electron microscope (SEM): Maximum magnification: Approximately 500 000x (1/2)

## Transmission electron microscope (TEM): Maximum magnification: Approximately 5 000 000x (1/2)

**f)** **Advantages:**

* The primary advantage is its powerful magnification.
* EMs also have many technological and industrial applications, such as semiconductor inspection, computer chip manufacturing, quality control and can even be used as part of a production line.
* Electron microscopes are used to investigate the [ultrastructure](https://en.wikipedia.org/wiki/Ultrastructure) of a wide range of biological and inorganic specimens including [microorganisms](https://en.wikipedia.org/wiki/Microorganisms), [cells](https://en.wikipedia.org/wiki/Cell_%28biology%29), large [molecules](https://en.wikipedia.org/wiki/Molecules), [biopsy](https://en.wikipedia.org/wiki/Biopsy) samples, [metals](https://en.wikipedia.org/wiki/Metals), and [crystals](https://en.wikipedia.org/wiki/Crystalline). Industrially, the electron microscope is often used for quality control and [failure analysis](https://en.wikipedia.org/wiki/Failure_analysis).

**Disadvantages:**

* Special training is required to learn the involved processes of specimen preparation, to minimize and recognize preparation-related artifacts and to operate the microscope itself.
* It needs to be kept in an area large enough to contain the microscope as well as protect and avoid any unintended influence on the electrons.
* The disadvantages of electron microscopes are primarily related to maintenance and sample preparation. Customers need to plan their budget to cover the cost of the unit, the maintenance, and the tools for proper sample preparation. Without these pieces in place, the readings of the unit may not be accurate!

g) Any 3 points like the ones below (3 marks)

* The electron microscope is an apparatus which permits scientists to see and photograph objects too small to be seen with an optical microscope.
* The electron microscope uses beams of electrons in place of beams of light.
* The magnifying power of the electron microscope is about 200 times that of the very best optical microscope.

h) References – In correct style / format (1) and minimum 2 websites or text info. (1)

**Total mark: /25**