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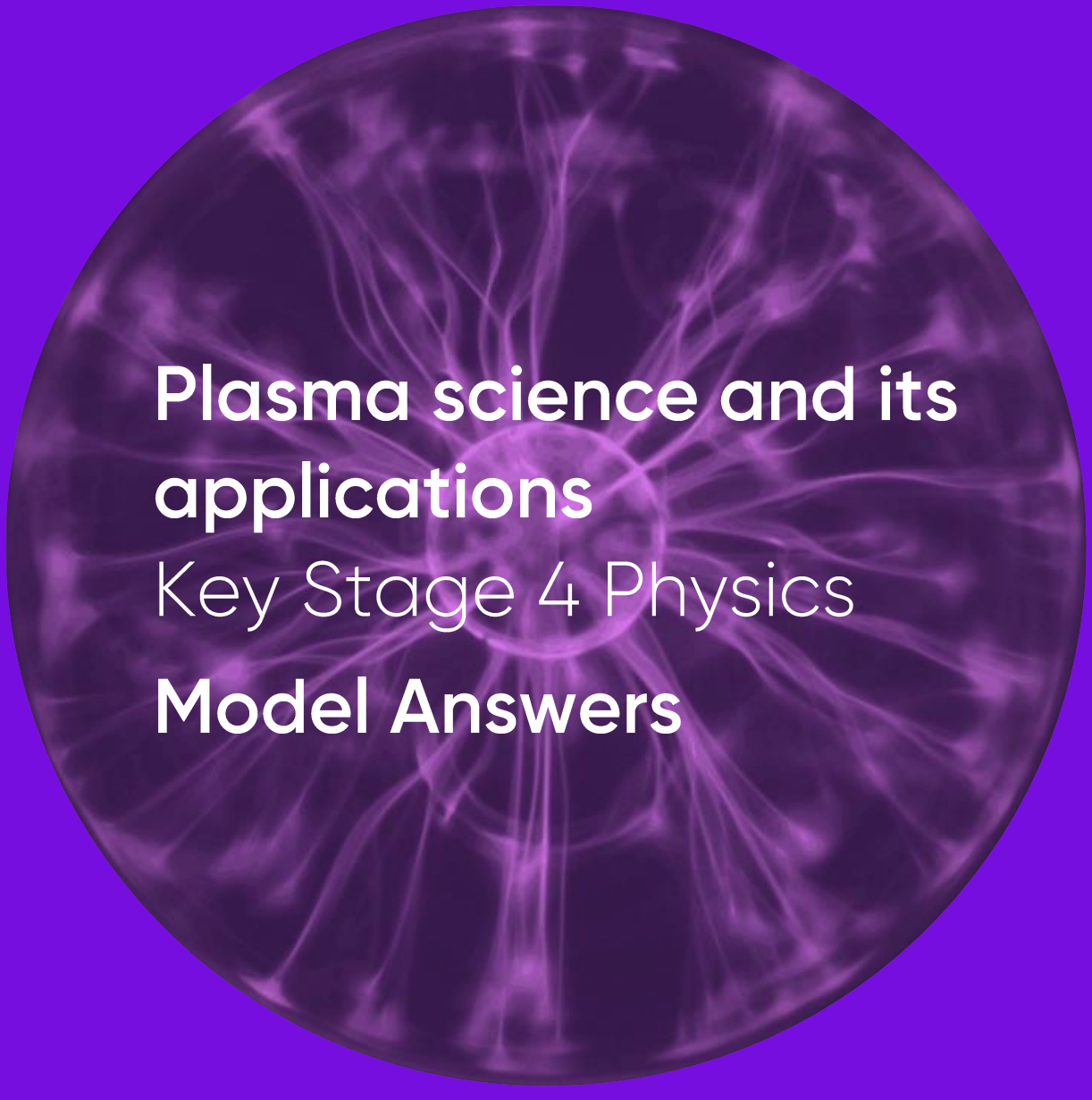

Plasma science and its applications

Key Stage 4 Physics

Model Answers

2019

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Resource One
Model Answers

Answers

1. Plasma is the fourth state of matter. It occurs when gas molecules separate into positive ions and negative electrons.
2. Naturally occurring plasmas include stars, lightning, and the ionosphere of the Earth's atmosphere. Among other places, artificially produced plasmas can be found in neon signs and plasma televisions.
3. In a hot plasma both the ions and electrons have high speed. In a cold plasma, the electrons have high speed but the motion of the ions can be ignored.
4. Uses of hot plasmas include destroying toxic substances in hospitals and the pharmaceutical industry. Uses of cold plasmas include in manufacturing electronic chips, DVDs and memory devices, and applying protective coating to surfaces, including medical devices and implants.
5. Plasma-based fusion provides a clean way of generating electricity. Unlike with fossil fuel and nuclear powerplants, carbon dioxide emissions and nuclear waste would not be an issue.

Resource Two
Model Answers

Answers

1. A thin film is a layer of material ranging from a fraction of a nanometre to several micrometres in thickness. A thin film that is one molecule thick is called a monolayer.
2. Optical coatings (such as antireflective coatings), hard coatings on cutting tools, thin-film solar cells, thin-film batteries.
3. A vapour is generated by boiling a target material. The vapour condenses on the substrate to form a thin film.
4. An electric arc is a visible plasma between two electrodes.
5. An arc heats up a cathode. The cathode material evaporates and condenses on the substrate to form a thin film.
6. In thermal evaporation, high temperatures are required to evaporate the target material. This would also melt some substrates if they have a low-melting point. Cathodic arc deposition can be done at room temperature, so the substrate material will not melt.

Resource Three
Model Answers

Answers

1. -
2. Because the substrate is now the negative cathode, the positive ions would be attracted to the substrate rather than the target.
3. 3a. If the incident ion energy increases the sputtering yield should increase. 3b. If the target binding energy increases the sputtering yield should decrease.
4. The ions are accelerated by the potential difference between the electrodes. The higher the potential difference the greater the acceleration of the ion, and the greater its energy. Therefore, ion energy depends on potential difference.
5. Sputter deposition is used to lay down thin layers of metal in the manufacture of hard disks, integrated circuits, DVDs, CDs. Sputtering is also used to coat specimens in metal for electron microscopy.
6. Sputter deposition can be conducted at low temperate (e.g. room temperature) while thermal evaporation needs high temperature. High temperature would damage circuit components.

Resource Four
Model Answers

Answers

1. Metals are used in heavy mechanical work and undergo wear. This results in a short lifetime of use. In order to length lifetime, nitriding is used to harden metal.
2. E.g. Drill components, automobile engines and jet turbine blades. These all undergo very heavy mechanical work – they interact with other metals and fluids at high speeds and temperatures. The need to be hardened to increase their lifespan.
3. 3a. In ammonia gas nitriding, a hot metal causes ammonia to dissociate into nitrogen and hydrogen, and the nitrogen diffuses into the metal surface. 3b. In cyanide salt nitriding, heating and melting the salt liberates nitrogen which can then diffuse into the surface of the metal that needs hardening. 3c. In plasma nitriding, nitrogen is ionised and accelerated by a potential difference toward the metal and is implanted in the metals surface.
4. Gas nitriding is safe but very slow. Cyanide salt nitriding is fastest but cyanide salt is toxic and poses a danger to staff performing the nitriding. Plasma nitriding is faster than gas nitriding and is safe to use.

Resource Five
Model Answers

Answers

1. Diffusion is the spreading out of particles resulting in a net movement from an area of higher concentration to an area of lower concentration.
2. Oxygen is at a high concentration int eh blood and a low concentration in the cells. Therefore, there will be a net movement of oxygen from the blood into the cells.
3. 3a. As the temperature increases, the rate of diffusion increases. 3b. As the viscosity increases, the rate of diffusion decreases. 3c. As the diffusing particle size increases, the rate of diffusion decreases.
4. In the primitive cubic structure, there is an atom at each corner of the unit. In body-centered cubic structure, there is an atom at each corner and in the centre of each unit. In the face-centered cubic structure, there is an atom at each corner and in the middle of each face of the unit.
5. The rate of diffusion increases with temperature. Because nitriding depends on the diffusion of nitrogen into the metal, nitriding will occur at a greater rate at higher temperatures.

Resource Six
Model Answers

Answers

1. Tribology is the science of interacting surfaces in relative motion, and includes the study of friction, lubrication and wear.
2. Studying material wear can help us understand how long a material will last for in a product,and what we can do to extend its lifetime
3. –
4. A ball is rotated in contact with a sample. The ball is covered in an abrasive slurry to cause wear of the sample.
5. Material A will have the smaller coefficient of wear. B) Hence material A is more wear resistant.

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