

Nanoparticles

Mark Scheme



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1. From medicine to sunscreens, nanoparticles are tiny particles whose unique properties are being used to develop a wide range of new technologies.

Circle the letter of the correct answer for each of the following questions.

- a) The width of a human hair is 1.4×10^{-4} m. A carbon nanotube has a width of 1.4×10^{-9} m. How many times wider the human hair is than the carbon nanotube.

D – is the only correct answer.	(1)
	Total: 1 mark

- b) Which of the following values represents a possible diameter for a nanoparticle?

B – is the only correct answer.	(1)
	Total: 1 mark

- c) A student wrote down four statements about nanoparticles. Which statement is scientifically incorrect?

B – is the only correct answer.	(1)
	Total: 1 mark

- d) Which property of nanoparticles makes them very effective catalysts?

C – is the only correct answer.	(1)
	Total: 1 mark

- e) Some modern plasters have a dressing that contains silver nanoparticles.

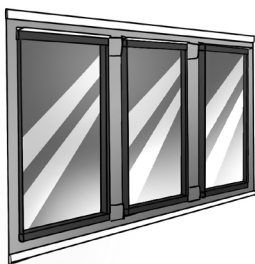


Which statement best explains the advantage of using silver nanoparticles in the plaster dressing?

D – is the only correct answer.	(1)
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. Self-cleaning windows are coated with a thin, transparent layer of titanium dioxide nanoparticles. This coating uses energy from sunlight to break down dirt that lands on the window.



- a) What is the typical size range of a particle that is classified as a nanoparticle?

1 nm to 100 nm	Allow: 1.0×10^{-9} m to 1.0×10^{-7} m	(1)
		Total: 1 mark

- b) Nanoparticles have a very high surface area to volume ratio.

A student is investigating how the surface area to volume ratio changes with the size of a cube.

Complete the table below by calculating the surface area, volume, and surface area to volume ratio for a cube with a side length of 10 cm.

Side length of cube (cm)	Surface area (cm ²)	Volume (cm ³)	Surface area to volume ratio
2	24	8	3
10	600	1000	0.6

Award 1 mark for each correct answer.	(1)
	Total: 3 marks

- c) Explain why a coating of titanium dioxide nanoparticles is more effective at breaking down dirt than a coating of fine titanium dioxide particles.

An explanation to include:	
They have a huge surface area to volume ratio.	(1)
Allow: More collisions on the surface.	
So, they act as effective catalysts / break down dirt faster (with sunlight).	(1)
	Total: 2 marks

- d) The use of nanoparticles in consumer products like self-cleaning windows is increasing.

Explain why some scientists are concerned about the potential long-term effects of using nanoparticles.

They are small enough to pass into cells / the bloodstream / through pores.	(1)
Long-term effects are unknown / They might damage healthy cells.	(1)
	Total: 2 marks

(Total for Question 2 is 8 marks)

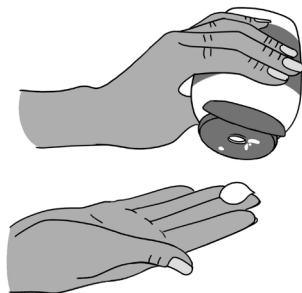
3. Nanoparticles are very small particles that have unusual properties.
Particles less than 100 nanometres in size are classified as nanoparticles.

a) 100 nanometres is:

B	(1)
	Total: 1 mark

Sunscreens work by creating a barrier on the skin that blocks harmful ultraviolet (UV) radiation given out by the sun from reaching the skin. Many modern sunscreens contain nanoparticles of zinc oxide.

Older sunscreens used fine particles of zinc oxide. Fine particles have a diameter of around 2,500 nanometres (nm).



b) Compare the sunscreen made with fine particles to the sunscreen made with nanoparticles.

Fine particles (2500 nm) are large enough to scatter light / appear white.	(1)
Nanoparticles are smaller than the wavelength of light / too small to see, so they appear transparent / invisible.	(1)
	Total: 2 marks

c) Explain why using nanoparticles of zinc oxide provides more effective protection from UV radiation than using the same mass of fine particles of zinc oxide.

Nanoparticles have a higher surface area to volume ratio.	(1)
So for the same mass of zinc oxide, there is more surface available to absorb/block UV.	(1)
	Total: 2 marks

d) The use of nanoparticles in sunscreens is a topic of debate.

Evaluate the use of nanoparticles in sunscreens.

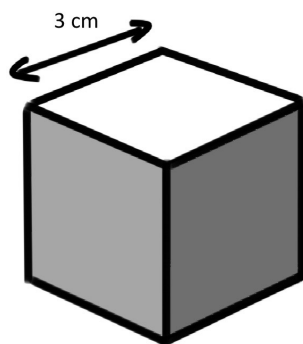
In your answer, you should refer to both the benefits and the potential risks.

Benefits any one from: - Better protection against UV / skin cancer. - Transparent (cosmetically better).	(1)
Risks any one from: - Can enter bloodstream / cells. - Could be toxic / damage cells. - Wash off into water / harm aquatic life.	(1)
Conclusion: Clear statement linking benefit vs risk (e.g., 'The benefit of preventing cancer outweighs the potential risk').	(1)
	Total: 3 marks

(Total for Question 3 is 8 marks)

4. Nanoparticles have many uses, including as catalysts.

A scientist investigates the properties of a cube of silver. The cube is shown in the figure below.



- a) Calculate the surface area to volume ratio of the cube of silver.

Show your working.

Surface Area:	$3 \times 3 \times 6 = 54$	(1)
Volume:	$3 \times 3 \times 3 = 27$	(1)
Ratio:	$54 \div 27 = 2$	
	Surface area to volume ratio = 2 : 1	(1)
		Total: 3 marks

- b) Explain why a certain mass of silver is more effective as a catalyst when it is in the form of nanoparticles compared to a coarse powder.

Nanoparticles have a much larger surface area to volume ratio (than coarse powder).	(1)
Allow: huge surface area.	
So, there are more silver atoms / active sites on the surface (available to react).	(1)
Leading to a faster rate of reaction / increased catalytic activity.	(1)
Allow: more frequent collisions or a higher frequency of collisions.	
Total: 3 marks	

(Total for Question 4 is 6 marks)

5. A company is developing a new method to purify water using silver nanoparticles, which have antibacterial properties. The effectiveness of the nanoparticles depends on their surface area to volume ratio.
- a) Calculate the surface area, volume, and surface area to volume ratio for the larger Particle B. Complete the table below.

Particle	Side length (nm)	Surface area (nm ²)	Volume (nm ³)	Surface area to volume ratio
Particle A	50	15 000	125 000	0.12
Particle B	2000			

Award 1 mark for each correct answer.	
Surface area (nm ²) = 24 000 000	(1)
Volume (nm ³) = 8 000 000 000	(1)
Surface area to volume ratio: = 0.003	(1)
	Total: 3 marks

- b) Using the data in the table above, explain why a given mass of Particle A would be more effective at purifying water than the same mass of Particle B.

Particle A has a much higher surface area to volume ratio.	(1)
So for the same mass of silver, Particle A has more surface area exposed to react with/kill bacteria.	(1)
	Total: 2 marks

- c) After purification, small traces of silver nanoparticles might remain in the drinking water and could eventually be released into the wider environment.

Evaluate the use of silver nanoparticles for purifying drinking water on a large scale.

Benefits any one from: - Kills bacteria / sterilises water effectively. - Prevents water-borne diseases (e.g. cholera). - Useful in remote areas / does not require power.	(1)
Risks any one from: - Nanoparticles could enter the bloodstream/cells. - Unknown long-term health effects on humans. - Toxic to fish/aquatic life if released into waste water.	(1)
Evaluation: A conclusion that weighs the immediate health benefit against the potential environmental/health risks.	(1)
	Total: 3 marks

(Total for Question 5 is 8 marks)