AQA

**Level 3 Certificate and Extended Certificate in Applied Science**
**January 2018**

# SCIENCE IN THE MODERN WORLD

# ASC3/PM

# Pre-release Material

- **This pre-released material should be opened and issued to learners on or after 1 November 2017.**

- **A clean copy of the pre-released material will be provided at the start of the examination.**

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## INFORMATION

**This pre-release material is to be issued to learners for use during preparation for this examination.**

**The pre-release material consists of four sources (A–D) on the subject of Microplastics.**

**This material is being given to you in advance of this examination to enable you to study each source in preparation for questions based on the material in SECTION A of the examination.**

**A wider understanding of the topics and issues raised in the sources would be beneficial for the assessment.**

**You are not required to understand any detailed scientific explanations BEYOND those outlined in Sources A–D and those in the Applied Science specification.**

**You may write notes on this copy of the pre-released material, but you will not be allowed to bring this copy, or any other notes you may have made, into the examination room. You will be provided with a clean copy of this pre-released material at the start of the examination.**

**It is suggested that a minimum of THREE HOURS detailed study is spent on this pre-released material.**

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**SOURCE A – adapted article from Education in Chemistry, first published on 15 November 2016 (no open access web permission).**

**The massive problem of microplastics**
**By Camilla Alexander-White (15 November 2016) adapted from Education in Chemistry cannot be reproduced here due to third-party copyright restrictions.**

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**SOURCE B – Extracts from House of Commons Environmental Audit Committee report on Environmental impact of microplastics. (Fourth Report of Session 2016–17)**

# Summary

**Microplastics are plastic particles smaller than 5 mm. They are used in some cosmetic and personal care products, and can be generated unintentionally, for example from abrasive sandblasting. Other microplastics result from the breakup of larger plastic objects in the oceans. It is estimated that a total of 15–51 trillion microplastic particles have accumulated in the ocean, with between 80,000 and 219,000 tonnes of microplastics entering the sea from Europe per year.**

**Our starting point for this inquiry was the significant public concern around the environmental impact of microbeads – a sub-set of microplastics that are intentionally added to cosmetic products and other toiletries, usually to exfoliate the skin. 680 tonnes of plastic microbeads are used in cosmetic products in the UK every year. Microplastics from cosmetic products are estimated to make up 0.01% to 4.1% of the total microplastics entering the marine environment. The fact that this accounts for a small percentage of total microplastic pollution in the sea does not stop it being a significant, and avoidable, environmental problem. We were told that a single shower can result in 100,000 plastic particles entering the ocean. Microbeads are also the source about which most is known. Addressing it would show commitment to reducing the wider problem of microplastics.**

A large proportion of the cosmetics industry has made voluntary commitments to phase out microbeads by 2020. However, we found that a legislative ban would have advantages for consumers and the industry in terms of consistency of approach, universality and confidence. We believe that the potential risks of such an approach – eg disadvantaging small firms – are proportionate and can be mitigated with proper consultation. Microbeads are a transnational source of pollution and there are advantages to dealing with it on an international basis. The Government has been considering a national ban and working towards an EU ban.

Despite the commitment by a section of the cosmetics industry to phase out microbeads we found a reluctance to talk publicly about the issue from large cosmetics manufacturers, and we found a lack of consistency in their approach. Therefore, we call on the Government to ban microbeads in the cosmetics industry, we believe this will level the playing field, and urge the Government to move swiftly towards implementation.

Microbeads are part of the wider issue of microplastic pollution. The small size of microplastics means that they can be ingested by marine life and have the potential to transfer chemicals to and from the marine environment. There is evidence of ecological damage resulting from this. If someone eats six oysters, it is likely they will have eaten 50 particles of microplastics. This is still a relatively new research area and subject to uncertainties. Relatively little research has been done so far either on potential impacts to human health or the marine economy. We recommend that the

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Government draw up a research strategy to assessing and mitigating microplastic pollution for the next round of research funding. Human health impacts should be a priority subject for research, along with examining ways to reduce microplastic pollution from consumer goods, such as synthetic fibres and tyres, and industrial processes, such as sandblasting.

We heard that preventing microplastics at source by stemming the flow of microplastics flushed into the oceans is the most viable option and should be the Government's key approach in its strategy. However, there are also opportunities to capture microplastics through washing machine filtration systems and waste and water sewage treatment processes. The Government and Environment Agency should work with water companies to understand whether feasible options exist to prevent microplastic pollution at this stage.

# Conclusions and recommendations

## Microplastic Pollution

- There is significant public concern around microbeads; however, they make up a small proportion of total microplastic pollution. The wider issue of microplastic pollution cannot be set aside once microbeads have been dealt with. We suggest that synthetic fibres and tyres are two sources that should be examined at an early stage.

- The impacts on the marine environment are still being researched. However, there is evidence that there is scope for significant harm to the marine environment. Microplastic pollution is potentially

more environmentally damaging than larger pieces of plastic because small pieces of plastic are more likely to be eaten by wildlife and have a greater surface area which can transfer chemicals to and from the marine environment.

- It is important to address microplastic pollution as a transnational problem and to understand that plastic in the ocean is in constant motion.

## Microbeads

- Experts have estimated that around 680 tonnes of plastic microbeads are used in the UK every year. A single shower can result in 100,000 plastic particles entering the sewage system. Microplastics from cosmetic products are believed to make up 0.01% to 4.1% of the total microplastics entering the marine environment. The fact that this accounts for a small percentage of total microplastic pollution in the sea does not stop it being a significant and avoidable environmental problem.

- Microbead pollution does not respect national borders. Legislative measures to prevent the sale or manufacture of microbeads will be more effective if undertaken on a transnational basis.

- We recommend that the Government introduce a legislative ban on the use of plastic microbeads in cosmetics and other toiletries.

- Microbeads have been particularly controversial because of the existence of several viable alternatives which do not have the same environmental impacts. Where those alternatives are natural in origin, companies should ensure they are sustainably sourced. Where they are artificially produced, they should ensure that appropriate environmental impact assessments are undertaken.

- Consumers should be able to tell whether the products they are buying contain microbeads. The industry is failing to label products containing microbeads clearly, and the companies we heard from were reluctant to change their labelling practices. Regulations for labelling are also failing to provide consumers with the clarity they need. In the absence of meaningful action by companies to label their products more clearly, we recommend that the Government introduces a clear labelling scheme for microbeads so that consumers may choose whether they wish to buy products containing microbeads. The industry told us that transparent labelling of microbeads would amount to an invitation not to buy products with microbeads in. Transparency to date has been provided by initiatives by NGOs. We recognise that this is a transitional issue and that there are costs associated with changing labels. Our preferred outcome would be a national ban on microbeads in cosmetics and toiletries by the end of next year. Failing that, we recommend that the Government introduce a clear labelling scheme for microbeads during the transitional period of a voluntary phase out to provide transparency for customers.

## Microplastic prevention and solutions

- The most effective solution to tackling microplastic pollution in the marine environment is to tackle it at the source. This means stemming the flow of primary microplastics, and general plastics, entering the marine environment in the first place. We heard that taking action to tackle ocean plastic pollution at source is the best strategy, and we believe that this is also the most feasible option in the short-term.

- We heard that prevention at source by reducing the number of microplastics flushed into the oceans is most viable. However, there are also opportunities to capture microplastics through effective waste and water sewage treatment processes which currently do not require the monitoring of microplastics. We recognise the heavy investment needed in this area, and that there is difficulty in filtering microplastics. Therefore, we recommend that the Government and Environment Agency work with Water Companies to understand what feasible options there are to monitor and ultimately reduce microplastic pollution.

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**SOURCE C: – an adapted article from The Guardian originally published on 24 August, 2016.**

# Microbeads – tiny objects, massive problem?

**There can be around 100,000 of them in the average face wash, but now MPs are calling for a ban and manufacturers are swapping plastics for ground-up peach-pits in products**

**Gavin Haynes**
**Wednesday 24 August 2016 17.45 BST**

**The late Dr John Ugelstad was a hero of Norwegian science. "Why go to space when you can go to Trondheim," Newsweek crowed on a visit to his labs in the 80s. It had come to photograph him in the company of a few of the millions of tiny particles – microbeads – he had invented. Prior to Ugelstad, it had been assumed that the only way to make tiny plastic polymers spherical was to do it in the weightlessness of space – the ones made on Earth had come out as useless droopy plastic soufflés. But Ugelstad had found a way, and the results were revolutionary.**

**In medicine, they allowed the separation of bodily substances to make testing much easier, especially for Aids. And in cancer, his "paramagnetic" (magnetic only in a magnetic field) microbeads allowed new treatments that would pile into bone cancer patients' bones and "scrub out" the old cancerous cells.**

**In cosmetics, though, his work has recently met with mixed reviews. This week, parliament's environmental audit committee called for a worldwide ban on cosmetic**

microbeads, found in everything from facewash to toothpaste to shampoo. And the scientific and political consensus has reached a tipping point. The US instituted a ban late last year, Canada did so in June, while the Dutch were on it back in 2014.

The evidence on microbeads has existed for almost a decade. A landmark study on North America's Great Lakes in 2012 used specially designed nets to drag the surface, finding tiny polymer spheres everywhere.

There are 100,000 in the average face wash, and estimates once put the number swirling down US plugholes every day at 808tn. Most end up in the sludge pile at the waste-water plant and are packed off for fertiliser. But 1% remains in solution – 8tn beads a day.

These then become snacks for microscopic plankton; soon enough the big fish eat the little ones, the beads start showing up in the stomachs of larger fish, and, in the Great Lakes study, also in fish-eating birds such as the double-crested cormorant.

Ugelstad was about to go down in history alongside the guy who invented asbestos and the bloke who put lead in petrol, but action by corporations seems to be turning the tide. In 2012, Unilever said it would stop using them, L'Oréal and Procter & Gamble have set timetables, while Boots ceased with its own brands in 2014. Some have simply deleted the ingredient (look for "polyethylene" or "polypropylene" on the pack). Others have instead turned to ground-up peach-pits, oatmeal or sea salt.

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**Rest assured, if you want to continue to sandpaper excess dermis off your face, to ritually grind your way back through gnarled exoskeleton back to the young you you know must be hiding in there somewhere, you still can. Just so long as you also respect the rights of the double-crested cormorant.**

**[End of Source C]**

**SOURCE D – an adapted article from Dermatology News originally published on January 18, 2016**

# Microbead ban could impede nanomaterial development

**Publish date: January 18, 2016**

**By: Sharon Worcester**
**Dermatology News**

**The new law that will ban the sale or distribution of plastic microbeads in over-the-counter and personal care products beginning in July 2017 could have an unintended effect: a negative impact on the development and acceptance of micro- and nanotechnology–based medical and diagnostic products.**

**Environmentalists and others cheered the new law for its potentially protective effects on the environment and ultimately on public health. And the unavailability of such products is not expected to adversely affect consumers, as there are alternatives to the scrubs and other products that contain these microbeads – and manufacturers have started to reformulate their products that contain plastic microbeads.**

**However, the ban could potentially do more harm than good if the message consumers hear is that microtechnology – and, by extension, nanotechnology – is bad, according to Dr. Adam Friedman, director of translational research in the department of dermatology at George Washington University, Washington, who is a Dermatology News Board Member.**

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**“What I’m most concerned about is the impact on public perception, that this ban infers that micro- and nanotechnology is inherently bad, and therefore, how it might impact approval of both over-the-counter and prescription medications that incorporate microscopic carriers,” said Dr. Friedman, who has a particular interest in nanotechnology. He explained that nanomaterials have enormous potential for helping to deliver drugs that are unstable, difficult to administer, or even toxic in their bulk form.**

**How such materials can be evaluated from a safety and efficacy standpoint in order to facilitate approval is currently under investigation, and negativity toward this field of research could hinder the progress of related research, he added, noting that “not all nano- and microtechnology is created equal.”**

**“This [ban] is about microplastics specifically,” not microspheres, -particles, or -beads, overall, he pointed out.**

**The basis of the Microbead-Free Waters Act of 2015 – which was signed into law by President Barack Obama on Dec. 28 after it sailed through Congress with an unusual level of bipartisan consensus among lawmakers regarding its importance – is that the plastic microbeads used in products such as facial scrubs and toothpaste pose a threat to marine life and ultimately to humans via the food chain.**

**Researchers have found that tiny microbeads – an estimated 11 billion daily – slip through wastewater treatment systems into the environment, where they appear to attract harmful chemicals that could make them toxic to marine life and ultimately to humans.**

In fact, the biological dangers associated with microbeads upon which the ban was based are hypothetical, Dr. Friedman countered, noting that much of the argument against microbeads is based on an oft-cited publication that is actually a non-peer-reviewed editorial in support of a microbead ban (Environ Sci Technol. 2015;49:10759-61). The authors cited studies demonstrating the inability of current sanitation measures to effectively remove the microbeads from the water supply. They also observed that "the argument has been raised that there is not yet enough scientific evidence to support banning microbeads," but added, "though there are gaps in our understanding of the precise impact of microbeads on aquatic ecosystems, this should not delay action."

Dr. Naissan O. Wesley, a dermatologist in private practice in Beverly Hills, noted that she, too is pleased about the concern regarding potential detrimental effects of microbeads. "This is a huge step in skin care for products that are healthy for us and our environment," she said, adding that while the quality of some products may be affected by the microbead ban, there are plenty of alternative scrubs, including sugar- or salt-based products.

Dr. Friedman also agreed with the importance of protecting the environment and the minimal impact the ban will have on products.

"I'm all for putting appropriate measures in place to prevent inappropriate exposures and damage to the natural setting. That said, I'm also for preserving the scientific method."

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**Taking microbead-containing products off the shelf is not a life-altering process, Dr. Friedman said, noting that he doesn't usually even recommend such products for patients. However, it will be expensive for the industry as it adapts to the microbead ban – and the money that will be spent is money that could have been applied to initiatives and efforts that may have had a bigger impact, he added.**

**"What frustrates me is that no opportunity was given to improve the technology," he said, explaining that nano- and microparticles could be augmented to prevent them from entering the water system. For example, surface modifications applied to the microbeads could be used to increase aggregation under specific environmental conditions, and thereby prevent filtration failure. "There was a missed opportunity to engage industry and scientists alike to better understand how materials at this scale behave and how they can be manipulated for good," he maintained.**

**"The ban opens the door to adversely impact more important technology that could be life altering. Now, we have an uphill battle."**

**Dr. Friedman and Dr. Wesley reported having no relevant disclosures.**

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