A

Level 3 Certificate/Extended Certificate

APPLIED SCIENCE

Unit 3 Science in the Modern World

June 2019

ASC3/PM

Pre-release Material

- **This pre-release material should be opened and issued to learners on or after 31 March 2019.**
- **A clean copy of the pre-release 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 ELECTRIC CARS.

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 that outlined in SOURCES A–D and that in the Applied Science specification.

You may write notes on this copy of the pre-release 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-release material at the start of the examination.

It is suggested that a minimum of three hours detailed study is spent on this pre-release material.

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SOURCE A: Adapted article from 'The Telegraph', July 2017

Electric cars - Historical landmarks

By Steven Swinford, Deputy Political Editor of the Telegraph

27 July 2017

1883 First electric production car

Although electricity had previously been used to power locomotives and model vehicles, English inventor Thomas Parker made the first production electric car.

c.1890 "Golden age"

Electric cars became a popular mode of transport, particularly among well-heeled city folk to whom the

vehicles' relatively short range was less of an issue.

c.1910 "Decline"

Improvements to the road network showed up electric cars' limited range. Cheaper petrol, technical and production refinements pushed the internal combustion engine to pre-eminence.

c.1931 Milk floats

Mainstream demand for electric cars was effectively dead. However, specialist manufacturers began producing local delivery vehicles such as the milk float, which dominated the world's electric vehicle market until the early 1980s.

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Late 1960s Concepts

The US Big Three carmakers researched electric propulsion systems, making many technical improvements. However, these largely failed to make it into production and were more like futuristic concept vehicles.

1985 Sinclair C5

Widely described as an electric car, the C5 was a concept vehicle launched by English inventor Sir Clive Sinclair. Sinclair was convinced that there was pent-up market demand for all-electric road transport. The C5 was a marketing disaster, driving its manufacturer into receivership within a year, although it went on to cult success with collectors.

1990 Impact

Triggered by volatile fuel prices,

General Motors promised to put its all-electric Impact concept into production.

Encouraged by this, the California Air Resources Board legislated that US carmakers would be required to make 2% of their fleet emissions-free by 1998, in order to continue trading in the smog-ridden state.

In response, carmakers produced a wide range of zero emission models. For example, the Chrysler TEVan, Ford Ranger EV, GM EV1, Honda EV Plus, Nissan Altra EV and Toyota RAV4 EV. Most large manufacturers withdrew these vehicles through the 1990s, citing a lack of enthusiasm from the general public. Their place was taken by small electric vehicles such as REVA's G-Whiz.

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2008 Tesla

Tesla put its Roadster model into production. The vehicle's commercial success sparked several major carmakers to re-examine their own electric vehicle programs to meet consumer demand.

2010 A new renaissance

Mitsubishi was quickest to meet the market with its MiEV hatchback in 2009. However, 2010 saw General Motors produce its hybrid Chevrolet Volt and Nissan produce its phenomenally successful Leaf.

Volvo, Ford, BMW, Honda, Toyota, Mercedes, Fiat and Renault were swift to follow with their own electric offerings over the next two years.

2013 Sales

The Tesla Model S became the first electric car to top the new car sales ranking in any country, as the top seller in Norway.

2016 One million

Cumulative global sales of electric cars and vans reached the one million unit mark in September 2016.

2017 Majority share

In January, the electrified passenger car market segment (consisting of hybrids and electric cars) outstripped the conventional motor segment (petrol or diesel), with 51.4% of new car sales.

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SOURCE B: Adapted article from 'Transport & Environment', December 2016

Beginning of the end for the internal combustion engine?

Published on December 12, 2016

This blog post was originally published as an opinion piece by Politico.

After many false dawns the electric car is finally on a trajectory to replace the internal combustion engine.

A recent report by Transport & Environment shows that by the end of the year there will be more than half a million battery, electric and plug-in hybrid vehicles on Europe's roads; and sales this year should account for 1.5 percent of the market. On the surface, the figures are modest but dig deeper and the electric vehicle (EV) earthquake

is finally shaking carmakers from their complacency.

The Paris Motor Show in October may well be remembered as a seminal moment.

Volkswagen launched its I.D. concept car, which is set for production in 2020 and will have an electric range of at least 400 kilometres. Herbert Diess, head of the VW brand, described the car as “revolutionary,” comparing its impact on the brand’s history to the Beetle or the Golf. This followed an earlier announcement that the VW Group aspires to get a quarter of its sales from electric by 2025 and is planning 20 models.

Mercedes launched an equivalent Generation EQ concept car that will become a new sub-brand with at least 10 plug-in models. Dieter Zetsche, its CEO, announced: “We’re now flipping the switch … ready for the

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launch of an electric product offensive that will cover all vehicle segments, from the compact to the luxury class."

In other announcements, Opel unveiled the Ampera-e (a European clone of the Chevrolet Bolt); and Renault and BMW detailed upgrades of the Zoe and i3 respectively, with Renault commenting: "Our vision of the electric market is that it is not a niche market."

So why are carmakers finally changing their attitude? Four recent developments have been particularly important in triggering action:

- The rapid growth in EV sales in China, which is now the world's biggest market and dominated by national manufacturers. Non-Chinese carmakers are desperate to succeed in this expanding market and terrified that their Chinese competitors, like BYD, will soon be successfully exporting to Europe;

- **The astonishing fall in the price of battery packs to around $150 per kilowatt hour. This makes EVs competitive with conventional vehicles. Also, it is possible to produce affordable EVs with ranges of over the important 300 kilometre range;**
- **The success of the Paris climate talks is driving a progressive tightening of car CO_2 emissions limits around the world, inevitably leading to a gradual phase out of fossil fuels. This has been hastened by the 'dieselgate' scandal and the realisation that the rest of the world will not be tricked into using diesel as a way to artificially reduce CO_2 emissions as Europe did;**
- **The remarkable pre-sales of the new Tesla Model 3 — a car for which 400,000 drivers put down $1000 each without even sitting in it. Suddenly**

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even German premium carmakers recognised that a true market exists and that they needed to supply it.

Fears that electric cars will decimate the value of the important European automotive sector also appear to be unfounded. VW has outlined plans for a €10 billion battery factory; Samsung SDI is to invest €320 million to build an electric-vehicle battery plant in Hungary; meanwhile LG Chem is reported to be planning a factory in Wrocław, Poland. Independent studies estimate that the shift will create between 500 000 and 1 million jobs by 2030.

Electric cars are not a panacea but together with e-bikes, electric scooters, trains and trams, they will provide the opportunity for a cleaner, greener mobility future that assigns dirty diesel cars and trains, which choke cities and commuters, to the scrapyard of

obsolescence. It is no longer a question of whether this happens — but how quickly.

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SOURCE C: Adapted article from 'The Guardian', August 2017

The Guardian view on electric cars: they'll change the world

Car drivers dream of freedom and autonomy but the future may be robotic public transport

Sunday 6 August 2017

The end of the age of the internal combustion engine is in sight. There are small signs everywhere: the shift to hybrid vehicles is already under way among manufacturers. Volvo has announced it will make no purely petrol-engine cars after 2019; the British government expects the all-electric future to arrive by 2040; and Tesla has just started selling its first electric car aimed squarely at the middle classes: the Tesla 3 sells for

$35,000 in the US, and 400,000 people have put down a small, refundable deposit towards one. Several thousand have already taken delivery, and the company hopes to sell half a million more next year. This is a remarkable figure for a machine with a fairly short range and a very limited number of specialised charging stations.

Some of it reflects the remarkable abilities of Elon Musk, the company's founder, as a salesman, engineer, and a man able to get the most out his factory workers and the governments he deals with. An LA Times investigation concluded that his enterprises have benefited from nearly $5bn in government subsidies, while the workers who actually build the cars used to have to put in 12-hour shifts, six days a week. The share price suggests that the company is bigger

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than Ford, though it makes a tiny fraction of the number of cars – and most years loses enormous sums of money. Mr Musk is selling a dream that the world wants to believe in.

This last may be the most important factor in the story. The private car is – like the smartphone – a device of immense practical help and economic significance, but at the same time a theatre for myths of unattainable self-fulfilment. The one thing you will never see in a car advertisement is traffic, even though that is the element in which drivers spend their lives. Every single driver in a traffic jam is trying to escape from it, yet it is the inevitable consequence of mass car ownership.

The sleek and swift electric car is at one level merely the most contemporary fantasy of autonomy and power. But it

might also disrupt our exterior landscapes nearly as much as the fossil fuel-engined car did in the last century. Electrical cars would of course pollute far less than fossil fuel-driven ones; instead of oil reserves, the rarest materials for batteries would make undeserving despots and their dynasties fantastically rich. Petrol stations would disappear. The air in cities would once more be breathable and their streets as quiet as those of Venice. This isn't an unmixed good. Cars that were as silent as bicycles would still be as dangerous as they are now to anyone they hit without audible warning.

The dream goes further than that. The electric cars of the future will be so thoroughly equipped with sensors and reaction mechanisms that they will never hit anyone. Just as brakes don't let you skid today, the steering wheel

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of tomorrow will swerve you away from danger before you have even noticed it. There is still some way to go yet, as witnessed in the case last year of a Tesla owner who watched a film at the wheel and was driven at high speed into the side of an articulated lorry that may have looked to the sensor like a patch of grey sky. But it's reasonable to suppose that there will be cars that can surmount most human stupidities within the next five or 10 years.

This is where the fantasy of autonomy comes full circle. The logical outcome of cars which need no driver is that they will become cars which need no owner either. Instead, they will work as taxis do, summoned at will but only for the journeys we actually need. This is the future towards which Uber, another Silicon Valley firm that has attained an immense valuation despite almost breathtaking losses, is working. The

ultimate development of the private car will be to reinvent public transport. Traffic jams will be abolished only when the private car becomes a public utility. What then will happen to our fantasies of independence? We'll all have to take to electrically powered bicycles.

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SOURCE D: Adapted article from 'CarbonBrief', July 2017

Analysis: Switch to electric vehicles would add just 10% to UK power demand

By Simon Evans 27.07.2017
www.carbonbrief.org

Earlier this week, UK environment secretary Michael Gove announced plans to ban the sale of new petrol and diesel cars by 2040.

The proposed ban, which may be less stringent than it first appears, has nevertheless sparked a deluge of news and comment. Many reports include concerns – or inflated claims – over the demand for power if the UK switches to electric vehicles (EVs).

Carbon Brief runs through the results and looks again at the debate over EV power demand.

Sales mix

In its model, developed for a 2015 report, Cambridge Econometrics assumes there is gradual progress towards a ban on sales of internal combustion engine (ICE) cars in 2040.

Given the lack of clarity over what type of cars will be covered by the ban, it simply assumes that hybrid petrol and diesel cars (HEV) are included, but plug-in hybrids (PHEV) are not.

Ultimately, battery electric vehicles (BEV) will dominate new sales. Cambridge Econometrics also explored the impact of an earlier ban on new ICE cars and vans, kicking in by 2030. The sales mix changes in a similar way, except BEVs take over earlier on. Next,

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the model looks at how new sales filter through the UK vehicle fleet, using data on average lifetimes and turnover rates.

The model then uses average vehicle tailpipe emissions and data on electricity demand per kilometre to estimate the environmental impacts of this overall fleet.

CO_2 emissions

Domestic transport currently emits around 120 million tonnes of CO_2 ($MtCO_2$) per year, roughly a fifth of the UK total. Tailpipe emissions from petrol and diesel cars accounts for around half of this, a little over 60$MtCO_2$ per year.

For either ban year, a rise in electric vehicle uptake dramatically cuts these emissions, the Cambridge

Econometrics modelling shows. If, on the other hand, there were no improvement in car emissions and the sector continued to emit 60MtCO_2 each year, this would be equivalent to half the UK's total carbon budget in 2050.

The Committee on Climate Change (CCC) suggests a more stringent 91% emissions reduction target for 2050 would be the midpoint of ambition needed to stay in line with the 1.5C of the Paris Agreement on climate change. In this case, 60MtCO_2 from cars would make up more than 80% of the UK's carbon budget in 2050.

These examples illustrate why, as Gove told BBC Radio 4 this week: "There is no alternative. We can't carry on with diesel and petrol cars, not just because of the health problems they cause, but also because the emissions that they

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cause would mean that we would accelerate climate change, do damage to our planet and to the next generation."

Returning to the new modelling, a 2040 ban on new sales would cut tailpipe emissions to around 14MtCO_2 in 2040, while a 2030 ban would see them fall to around half that level, or 7MtCO_2.

Tailpipe emissions would continue to fall after the ban on new sales kicks in, as zero-emissions EVs work their way through the stock of cars and plug-in hybrids lose market share.

Generating CO_2

The additional electricity demand from EVs could increase emissions in the power sector, depending on how the electricity is generated. This would partially offset the gains in tailpipe

emissions, but only to a very limited extent, according to Cambridge Econometrics' model.

For example, with a 2040 ban, tailpipe emissions fall to 14MtCO_2 that year, with additional power sector emissions adding just 4MtCO_2 to the total. This limited impact is partly down to expected improvements in the emissions rate of the power sector, which is gradually cutting the amount of CO_2 per unit of electricity, in line with UK climate goals.

Note that EVs offer CO_2 savings even under relatively CO_2-heavy electricity grids including coal-fired generation. This is because EVs are more efficient than combustion-engine cars. Similarly, the CO_2 associated with manufacturing EV batteries is more than offset by

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savings during EVs' lifetimes.

A comprehensive literature review from the International Council on Clean Transportation (ICCT) says EVs offer CO_2 savings of 40-50% compared to average combustion engine vehicles. This includes full lifecycle emissions including manufacture, use and electricity generation, based on an EU average grid mix. This means EVs could cut global emissions by 1.5 billion tonnes of CO_2 per year in 2050, a second ICCT study says.

Cumulative CO_2

A 2030 ban on new sales would force earlier adoption of zero-emissions vehicles, aiding UK progression towards its carbon targets. For comparison, the CCC says close to 100% of new sales should be

zero-emissions by 2035, if the UK is to stay on track with its goals.

There is a relatively small difference in emissions between the 2030 and 2040 ban scenarios modelled by Cambridge Econometrics. However, this small difference could still be significant when compared to the UK's shrinking carbon budgets, which reach around 120MtCO_2 in 2050.

Adding together savings at the tailpipe, minus extra emissions from power stations, a 2030 ban would cut UK CO_2 by an additional 6MtCO_2 in 2040, compared to a ban that only begins in 2040. This is equivalent to roughly 2.5% of the UK's carbon budget in that year.

Cumulative savings could reach 123MtCO_2 by 2050, if there is an earlier

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2030 ban instead of the currently proposed 2040 date.

Peak demand

EV charging is expected to raise peak UK power demand, as well as increasing electricity needs across the course of a year. If EV charging is uncontrolled, this increase could be very substantial, placing undue strain on the electricity grid or requiring high levels of investment.

This worst-case scenario has been the focus for a number of news and comment articles, as well as wider commentary by radio and TV personalities, all presenting it as an inevitable consequence of a switch to EVs. The Telegraph, for example, says:

“The extra electricity needed will be the equivalent of almost 10 times the total

power output of the new Hinkley Point C nuclear power station being built in Somerset."

There are several unrealistic assumptions behind this misleading media narrative, which Carbon Brief covered in an earlier fact check. Chief among them is the intuitively appealing idea that EV owners will all return home from work around the same time and immediately start charging their cars.

This simplistic view ignores the evidence from existing EV users. Some domestic customers already take advantage of dual-rate Economy 7 tariffs to charge their cars cheaply at night, while others plug in to public charging points while they are at work.

In fact, EV charging reaches a peak two hours later than expected, at 9pm, outside the period of overall peak UK

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demand, according to research for the electricity distribution firm UK Power Networks.

Earlier ban

In an article explaining its new analysis, Cambridge Econometrics says:

“Some have questioned why the ban is not being introduced earlier. The share of low and zero-emission vehicles will rise rapidly in any case, supported by European legislation, as electric vehicles become more attractive to consumers, with costs falling and battery range increasing.”

According to projections from analysts Bloomberg New Energy Finance, around 80% of cars sold in the UK are likely to be electric by 2040, even if there is not a petrol and diesel ban. This would leave less than 20% of sales for

internal combustion engine vehicles or hybrids.

Despite these optimistic outlooks, Cambridge Econometrics go on to say that there are challenges to a 2030 ban, which “need to be addressed to realise the benefits”. These hurdles include meeting the infrastructure and energy needs of EVs, as well as building a new manufacturing base and retraining the sector’s already-skilled workforce.

A Times editorial and a Guardian comment are among those arguing that the 2040 ban is too late, given the air pollution crisis facing the UK. The Times says:

“Ministers are under a legal obligation to cut [air pollution] emissions to safe levels in the ‘shortest possible time’. Waiting until 2040 does not fulfil that

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obligation and obvious ways to accelerate the process are being left untried.”

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