

Academic Reading Paper 19

Converters, Ants and Survivors

Time allowed: 1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this booklet until you are told to do so.
- Write your name and the date at the top of the answer sheet.
- Answer **all** the questions.
- Write your answers **on the answer sheet**, not in this booklet.
- You must transfer your answers within the hour. **No extra time is given for transferring answers in the Reading test.**
- Do not remove this booklet from the examination room.

INFORMATION FOR CANDIDATES

- There are 40 questions in this paper.
- Each question carries one mark.
- There are three passages, with 13, 13 and 14 questions.

These passages were written for this library. They are **not** reproduced from any published past paper. The format, timing and task types follow the published specification for the Academic Reading test so that sitting this on paper feels like the real thing.

You should spend about 20 minutes on Questions 1–13, which are based on Reading Passage 1 below.

Twenty minutes instead of a fortnight

In August 1856 Henry Bessemer told a meeting of the British Association that he could turn pig iron into steel without using any fuel at all. The claim sounded like nonsense and the demonstration was not. Molten pig iron was poured into a pear-shaped vessel and cold air was blown up through it from below, and instead of chilling the metal the blast made it roar and throw flame for twenty minutes, after which the vessel was tipped and steel ran out of it. Before that morning, converting a comparable quantity by the older method took several days of a skilled man standing over a furnace stirring the metal with a rod.

The trick is that the air does the heating. Pig iron straight from a blast furnace carries several per cent of carbon along with silicon and manganese, and those elements burn when oxygen reaches them. Burning them releases enough heat to keep the whole mass liquid and to raise its temperature further, so the fuel is not something added to the vessel; it is the impurity already dissolved in the metal, and the process runs until that fuel is used up. The economics followed at once. Steel had been a material for springs and cutlery, sold by the pound, and it became a material for rails and bridges, sold by the ton.

What happened next is the part that gets left out. Licences were bought within weeks for very large sums, the licensees built their vessels, and every one of them produced metal that was useless. It cracked, it could not be rolled, and it was worth less than the iron it had been made from. Bessemer, who had run the process successfully himself, could not explain the failures, and for a period of about two years the invention was regarded in the trade as a fraud that had already taken its money.

Two separate faults were at work, and they were found by two men who were not Bessemer. The first is a consequence of how well the process works. The blast does not stop politely at the right amount of carbon; it takes out effectively all of it, and it leaves the metal full of dissolved oxygen, which is what makes the product brittle. Steel is iron with a controlled and quite small quantity of carbon in it, so the answer is to blow everything out and then put back exactly what is wanted.

Robert Mushet supplied that answer in the same year. He added a measured quantity of spiegeleisen, an alloy of iron with manganese and carbon, to the blown metal. The manganese takes up the dissolved oxygen and leaves as slag, and the carbon that comes with it restores the amount the steel is supposed to contain. It is a two-line recipe and it made the process work. Mushet failed to pay the renewal fee on his patent, which therefore lapsed, and he received nothing for it until Bessemer, years afterwards and under no obligation, granted him an annual payment.

The second fault took twenty-two more years and explains why the failures had been so uneven. Phosphorus in iron makes steel brittle when cold, and the lining Bessemer used inside his vessel was siliceous, which is chemically acid and cannot hold phosphorus at all. Whatever phosphorus was in the pig iron stayed in the steel. Bessemer's own supply happened to come from ore that contained almost

none, so his demonstrations worked. Most British ore, and nearly all of the enormous deposits in Lorraine and the American Midwest, is phosphoric. The licensees were not incompetent. They were using the wrong rock, and neither they nor Bessemer knew that the rock was the variable.

The correction came from outside the industry. Sidney Gilchrist Thomas was a clerk in a London police court who attended evening classes in chemistry, and he reasoned that if an acid lining could not take up phosphorus then a basic one would. With his cousin Percy Gilchrist, a works chemist who could test the idea at scale, he lined a converter with burnt dolomite and added lime to the charge, and the phosphorus went into the slag where it belonged. The result was announced in 1879.

The consequences were larger than the invention it repaired. Ore fields that had been worthless for steel-making became the basis of the German and American industries, and the phosphate-rich slag was ground up and sold to farmers as fertiliser, so the waste paid for part of the process. Bessemer's name is on the converter, and the two things that made it usable were contributed by a man whose patent lapsed and a police-court clerk with an evening-class education.

Questions 1–6

Complete the notes below.

Choose **NO MORE THAN TWO WORDS AND/OR A NUMBER** from the passage for each answer.

What Bessemer demonstrated in 1856

The vessel

- Molten pig iron is poured into a **1** vessel.
- Cold **2** is blown up through the metal from below.
- The blast lasts about **3** minutes.

Why no fuel is needed

- Pig iron carries several per cent of **4** , along with silicon and manganese.
- Burning those elements keeps the mass liquid, so the fuel is the impurity already in the metal.

What changed

- The older method needed a skilled man stirring the metal with a **5** for several days.
- Steel stopped being sold by the pound and began to be sold by the **6**

Questions 7–9

Complete the sentences below.

Choose **NO MORE THAN TWO WORDS AND/OR A NUMBER** from the passage for each answer.

- 7** The manganese in Mushet's addition takes up the dissolved and leaves as slag.

- 8 Thomas lined a converter with burnt and added lime to the charge.
- 9 The solution to the phosphorus problem was announced in

Questions 10–13

Do the following statements agree with the information given in Reading Passage 1?

Write **TRUE** if the statement agrees with the information, **FALSE** if the statement contradicts the information, or **NOT GIVEN** if there is no information on this.

- 10 The Bessemer process requires no fuel to be put into the vessel.
- 11 Bessemer knew at the time that his own ore was unusually low in phosphorus.
- 12 Bessemer bought Mushet's lapsed patent.
- 13 Percy Gilchrist was the police-court clerk who proposed the basic lining.

You should spend about 20 minutes on Questions 14–26, which are based on Reading Passage 2 below.

The ant that counts its steps

- A** A desert ant of the genus *Cataglyphis* leaves its nest in the Sahara, searches for a dead insect across ground that offers almost nothing to steer by, and wanders as much as a hundred metres in a path that loops and doubles back on itself. When it finds food it does not retrace that path. It turns and runs almost straight to the nest, which is a hole a few millimetres across in an otherwise featureless plain, and it does this at a surface temperature that would kill it within minutes if it got the direction wrong. It carries no trail of scent behind it, because a pheromone track would evaporate off ground that reaches sixty degrees. The question of how it does so has been worked on for over a century, and the answer has turned out to have three separate parts.
- B** The first part was established in 1911 by Felix Santschi, a Swiss doctor working in Tunisia, with an experiment that needed no equipment beyond a piece of board and a mirror. He shaded a homing ant from the sun and used the mirror to show it the sun's reflection from the opposite side. The ant turned and ran in the mirror-image direction. It was steering by the sun, which was not obvious at the time, and it was steering by it well enough that a false sun was enough to reverse the whole journey. Santschi went on repeating the trick on ant after ant, and the reversal came every time, which is why an experiment done with a shaving mirror is still cited.
- C** Later work showed that the compass is better than that, because the sun is often behind a dune or directly overhead and the ant carries on regardless. What it reads is the pattern of polarised light across the sky, which is produced by scattering in the atmosphere and holds a fixed geometric relationship to the sun's position. A specialised band of receptors along the top edge of the eye is tuned to it. A patch of clear sky the size of a hand is enough to recover the direction, and the ant's compass therefore works when the sun itself cannot be seen. Human eyes cannot detect the pattern at all, which is part of why it took so long for anyone to suspect that an animal was navigating by it.
- D** A compass alone would not get the animal home. Knowing which way is north does not tell you how far away the nest is, and the ant runs the correct distance as well as the correct bearing: displaced by an experimenter after finding food, it runs the vector it would have needed from the place it was captured, arrives at empty sand, and then begins a systematic search of loops around that point. That behaviour is the signature of dead reckoning, or path integration, in which an animal continuously adds up the directions and distances it has travelled and holds the running total as a single homeward vector.
- E** How the distance is measured resisted explanation for decades, and the demonstration when it came was startling in its simplicity. Matthias Wittlinger, working with Rüdiger Wehner and Harald Wolf, let ants walk out to a feeder and then altered their legs before the return trip. Some had pig-bristle stilts glued on, lengthening the stride; others had the ends of their legs shortened. The stilted ants ran past the nest and began searching beyond it. The shortened ants stopped short and

searched before reaching it. Both groups had run the right number of steps, and the wrong distance. The overshoot and the undershoot were close to the proportions by which the legs had been altered.

- F** That is close to a direct reading of the mechanism: the animal is counting strides, or something that scales with them, rather than measuring ground covered by any external means. Ants fitted with stilts before the outward journey, so that they used the same legs in both directions, went home correctly, which is the control the result needed. What the pedometer cannot do is find a hole a few millimetres wide, because small errors in every segment accumulate along the way, and the vector therefore delivers the ant to a region rather than to a point.
- G** The last few metres are done another way. Around the nest the ant has learned the appearance of the horizon from that spot, and it moves so as to reduce the difference between what it now sees and the remembered view, which is why an experimenter who moves nearby landmarks can shift the search centre by the same amount. Three mechanisms are therefore doing three jobs: the sky gives a bearing, the legs give a distance, and the surroundings give the final few metres. None of them would be sufficient alone, and the animal running the whole sequence has a brain of about a quarter of a million neurons.

Questions 14–20

Reading Passage 2 has seven sections, A–G.

Choose the correct heading for each section from the list of headings below.

Write the correct number, I–X.

List of Headings

- i** A journey that follows a trail left behind
- ii** A journey that leaves nothing to follow
- iii** Proof that the animal steers by the sun
- iv** A compass that needs the sun to be visible
- v** A compass that works when the sun cannot be seen
- vi** Running the right bearing and the right length
- vii** Evidence that distance is measured, not counted
- viii** Evidence that distance is counted, not measured
- ix** The limits of the running total
- x** Three systems, each doing one job

14 Section A

15 Section B

16 Section C

17 Section D

18 Section E

19 Section F

20 Section G

Questions 21–24

Label the diagram below.

Choose **NO MORE THAN TWO WORDS** from the passage for each answer.

One foraging trip, and how the ant gets back

• 21 the hole a few millimetres across that the ant is returning to

• 22 the single straight quantity the ant holds as a running total

• 23 the loops the ant makes on arriving at the wrong place

• 24 what a hand-sized patch of sky supplies for the bearing

Questions 25–26

Choose the correct letter, A, B, C or D.

- 25 What was the control in the stilts experiment?
- A Ants given stilts before the outward journey went home correctly.
- B Ants without stilts searched at random.
- C Stilts were shown to make the ants walk more slowly.
- D The measurements were repeated on a second colony.

- 26** According to the passage, moving landmarks near the nest makes the ant
- A** shift the centre of its search by the same amount.
 - B** shift the centre of its search in the opposite direction.
 - C** search over a much wider area.
 - D** return to the feeder it came from.

You should spend about 20 minutes on Questions 27–40, which are based on Reading Passage 3 below.

Why old technologies survive

We describe technology by its newest examples and then wonder why the world does not look like the description. Talk about transport means talk about electric cars and autonomous vehicles; the largest movement of goods on the planet is by ship, using a hull form and a diesel engine that would not surprise an engineer from 1960. Talk about communication means talk about whatever platform is current; the fax machine was still in daily use in Japanese and German offices decades after everyone agreed it was obsolete. The pattern is consistent enough that the exceptions need explaining rather than the rule.

The usual account of this is a story of replacement. A better technology appears, it is adopted because it is better, the old one dies, and anything that lingers is doing so out of habit, sentiment or institutional stupidity. It is a satisfying account and it fits the cases everyone quotes. The trouble is that it makes a prediction that keeps failing: things that ought to be dead are not, and they are frequently being used by exactly the people who have the most to gain from being right about them.

The opposite story is worse. In this one the old technology is quietly superior, the new one is a fashion, and the persistence of the old proves the point. Vinyl is said to sound better, paper to be read better, handwriting to be remembered better. Occasionally there is something in it, but as a general account it fails immediately, because the great majority of old technologies did die, and they died because the replacement was in fact better at the thing they were for. Anyone defending the general claim has to explain the gaslight, the telegraph and the horse.

The pattern that actually holds is narrower and less flattering to both sides. A technology survives where it occupies a niche the replacement does not cover, and the replacement is usually not designed to cover it, because the niche is defined by a requirement nobody thought to write down. Paper charts survive on ships not because sailors distrust satellites but because paper does not stop working when the power does. Freight rail survives against road haulage on exactly the routes where the load is heavy, the distance is long and nobody is in a hurry, which is the case the lorry was never optimised for.

Seen that way the persistence is information rather than inertia. Each surviving old technology is a marker on a requirement the new one has failed to meet, and the requirement is often invisible until you look at what the survivor is doing. That the fax lasted in some countries and not others is a fact about signatures and legal recognition, not about telecommunications. That film is still used by a few cinematographers is a fact about the response of an emulsion to overexposure. In every case the interesting question is not why they cling to it, but what it does that the new thing does not.

There is a further effect that is easy to miss, and it cuts against the tidy replacement story from the other end. A technology under threat often improves faster than it ever did while unchallenged. Sailing ships reached their highest speeds and their largest tonnages after steam was already established, because the competition forced work that nobody had bothered to do. The same has happened to the internal com-

bustion engine, to the mechanical watch, and to printed newspapers in their design if not their finances. The arrival of the successor is frequently the beginning of the predecessor's best period rather than the end of it.

None of this is an argument for keeping things. Most of what is being defended on these grounds really should be replaced, and the person defending it is usually not making the argument above; they are making the sentimental one and hoping it will pass. The point is about what to do before replacing something, which is to find out what the old arrangement was actually doing, including the parts nobody specified, because those are the parts the replacement will silently drop and the failure will arrive later and be blamed on something else.

The general form of the mistake is treating the age of a technology as evidence about its value in either direction. Old is not a reason to keep and it is not a reason to discard. What matters is the list of requirements the thing quietly satisfies, and that list is not held by the people selling the replacement, nor by the people defending the incumbent, but is usually written down nowhere and known only in the hands of whoever has to use it when something goes wrong.

Questions 27–31

Do the following statements agree with the claims of the writer in Reading Passage 3?

Write **YES** if the statement agrees with the claims of the writer, **NO** if the statement contradicts the claims of the writer, or **NOT GIVEN** if it is impossible to say what the writer thinks about this.

- 27** The writer thinks anything surviving an improved technology does so through inertia.
- 28** The writer accepts that most old technologies really were replaced by something better.
- 29** Sailing ships were faster than early steamships on most routes.
- 30** The writer says that people who defend old technologies usually make the argument he has set out.
- 31** The writer holds that a technology's age settles nothing either way.

Questions 32–36

Complete each sentence with the correct ending, A–H, below.

Endings

- A that anything surviving is doing so out of habit or sentiment.
- B has to explain the gaslight, the telegraph and the horse.
- C they go on working when the power does not.
- D is a fact about signatures and legal recognition.
- E after their successor was already established.
- F sailors do not trust satellite systems.
- G proves that new technologies are usually a fashion.
- H before steam had appeared at all.

- 32 The replacement account predicts
- 33 Anyone claiming that old technologies are generally superior
- 34 Paper charts remain on ships because
- 35 The fax machine's survival in particular countries
- 36 Sailing ships reached their greatest speeds

Questions 37–40

Choose the correct letter, A, B, C or D.

- 37 Why does the writer mention freight rail?
 - A To show that lorries are badly designed.
 - B As a case the replacement was never optimised for.
 - C To argue that road haulage should be reduced.
 - D To show that rail is cheaper over every distance.
- 38 Which position does the writer reject?
 - A That most old technologies did in fact die out.
 - B That persistence points to an unmet requirement.
 - C That how old a technology is tells you what it is worth.
 - D That a threatened technology can improve.

- 39** The writer says the requirement that keeps an old technology alive is usually
- A** recorded in a written standard.
 - B** written down nowhere.
 - C** known to those selling the replacement.
 - D** obvious to everyone concerned.
- 40** Which of the following best expresses the writer's advice?
- A** Find out what the old arrangement was doing before replacing it.
 - B** Keep old technologies wherever it is possible to do so.
 - C** Replace old technologies more quickly than we do.
 - D** Sentimental defences of old technology are usually dishonest.