Question 1:

Dear Cheap Astronomy – Can we terraform Venus?

Well maybe, though it would require some very advanced planetary engineering and huge amounts of energy. And whether you could then keep Venus terraformed without ongoing engineering interventions looks doubtful, although you could probably say the same for Mars terraforming plans.

The first issue you have to deal with is Venus' atmosphere, which is very dense and crazy hot because of its primarily CO_2 composition. There are several options, the first being chemistry, where we could add hydrogen to produce graphite and water. Of course this would require 40 quintillion kilograms of hydrogen, which you'd probably need to ship from Jupiter. Apparently you'd also need a moderate amount of aerosolised iron to make the reaction happen, which is proposed to be mined from Mercury and then aerosolised throughout Venus' atmosphere… somehow. An easier and less science-fictiony alternative might be to bury all the CO_2 – using CO_2 sequestration techniques, which may already be achievable on a small scale on Earth using current technologies, except it's expensive and the outcome would just be global benefit rather than individual or national benefit – so for now we're just watching all our forests burn.

Anyhow, just dealing with the atmosphere doesn't deal with the issue that Venus receives around twice as much solar flux as the Earth does. The best solution to deal with that is some kind of solar shade, ideally a structure with four times the diameter of Venus sitting at the Sun-Venus Lagrange point 1. This would also help reduce the solar wind pressure, which will otherwise blow any terraformed atmosphere. Trouble is, if your solar shade is deflecting solar wind as well as photons, it will get pushed out of position over time. So the shade might need louvres to let some wind particles and photons through at particular angles. Another idea is to start colonizing Venus with lots of cloud cities that have reflective surfaces – and those cities could be built from carbon extracted from the atmosphere, which would mean the first stages of colonization were contributing to the later stages of colonisation, by both shading the planet and thinning the atmosphere.

A whole different approach is that you first cool the atmosphere right down with extreme shading so as to freeze all the CO_2 out into solid form. Then you just lift the CO_2 off the planet – perhaps shipping it to Mars to help with the terraforming effort there. Also, if we launched big chunks of it at escape velocity all in the same angular direction, we could increase the spin of the planet. Freezing out the dense CO_2 atmosphere would form an ice crust several hundred meters thick, so you would have a substantial amount of mass to work with.

Or we could apply that same idea in reverse by bombarding Venus with objects from the outer solar system, aligning the trajectories of those bombarding objects so as to increase Venus' spin rate. Such heavy, sustained bombardment would thin the CO_2 atmosphere by just blowing a lot of it into space. And if you ensured the bombarding objects were primarily water ice, you would also be adding water to the surface. Mind you, there is some debate about whether we do want to spin Venus faster. Once you've got rid of most of the CO_2 and have water oceans, the sunlit side will always be covered with high albedo clouds which will cool the light side and the dark side will be cool anyway, because it's dark. So spinning Venus faster could end up making the average surface temperature hotter.

Nonetheless, a key advantage to spinning up Venus might be to give it a magnetic field like Earth's and protect the newly-terra formed atmosphere from being blown away by the solar wind (assuming the giant louvered sunshade isn't enough). But if we didn't want to spin it faster and sunshade wasn't enough we could just deploy refrigerated superconducting rings latitudinally around the planet, or we position a giant magnetic dipole at the L1 Lagrange point – either method producing an effective artificial magnetosphere. Heck with this sort of thinking it's a wonder we haven't moved in already.

Question 2:

Dear Cheap Astronomy – Please tell us more about standard candles?

As we've discussed before on Cheap Astronomy our understanding of the Universe is a bitsy construction, where we know what some bits are, but we don't know other bits are – although we are pretty sure they are bits. The bits that we do know about only make up 5 per cent of all the bits – in other words 95 per cent of the Universe is composed of dark bits. And even then… the subject of this episode is to question our confidence about the 5% of the story that we think we know about.

So, if you have a standard candle that's always of a certain brightness then you can determine whether it's close or distant, based on whether it's bright or dim. However, a fundamental problem with astronomical standard candles is that the further away they are, the further back in time they were when the signals you receive about them were first emitted. It's subsequently become clear that Edwin Hubble's measurements, which established a linear relationship between distance and red shift, using Cepheid variables as standard candles, were actually way off. We've subsequently realized that nearby Cepheid variables are population 1 stars, that is recent generation stars, while distant ones are population 2 stars, that is, older generation stars with lower metallicity. Those lower metallicity population 2 stars were brighter than the standard that Hubble had assumed and hence were a lot further away than Hubble had assumed. The recalibration of Hubble's measurements resulted in a doubling of the estimated distances of other galaxies, as well as doubling the estimated size of our own galaxy.

In a similar vein, there is some doubt about our current estimates of the Universe's expansion rate based on Type 1a supernovae. Type 1as are assumed to be standard candles, so the dimmer they are the further away they are. We can also do what Hubble did with Cepheid variables and measure both their distance and their red shift. So the further away one is the more red-shifted it is, indicating that it's moving away from us faster than close ones are – so demonstrating the Universe is expanding. And the speed variations in very distant type 1s from the early Universe and close ones from the recent Universe also confirm the Universe's expansion has been accelerating over time.

Much like the Cepheid variable observations, if it turns out that Type 1a supernovae aren't quite the standard candles we thought they were - perhaps because Type 1as from the early Universe explode a bit differently from Type 1as in the more recent Universe, then it will mean our distance measures are a bit out, but it's not likely this would undermine the fundamental conclusion of accelerating expansion, we'd just gain a more precise measure of the expansion rate, commonly known as the Hubble parameter.

Nonetheless, we are apparently in the midst of a crisis in cosmology, where different methods used to measure the Hubble parameter are delivering different numbers. So, for example you can estimate the rate of expansion from observing the cosmic microwave background against the current distribution of galaxies. However this gives you a slower rate than the standard candle measurements do. It's not clear whether we are just dealing with a lack of precision is these different measurements or whether there is something fundamentally wrong with the assumptions underlying the calculations, meaning our theoretical schema about the Universe could be fundamentally wrong. But, whether this is really a crisis or just scientific business as usual is largely a matter of perspective. Not knowing everything is what keeps scientists in business.

One way to deal with the apparent crisis is to look for other methods of measuring distances and expansion rates. For example, thanks to gravitational wave astronomy we also now have standard sirens, where the collision of two neutron stars should create a standard chirp signal that attenuates with distance and you can calibrate that distance by also observing the location of the binary through electromagnetic astronomy, that is normal astronomy – if there really is such a thing as normal astronomy.