Question 1:

Dear Cheap Astronomy – When worlds collide

The outcome of a collision between two planets depends on the speed of the collision, the angle of the collision and the relative masses of the two bodies and their composition – think rocky planets versus gas giants for example. A small planet approaching a large planet slowly might get tidally stretched and break up into pieces, but a fast moving one might impact before there's been time for gravitational stretching to break it up. A slow planet approaching another on an oblique angle, might end up in orbit around the other – or more correctly both would orbit around their common centre of mass – the orbit would decay over time and the planets would eventually merge, but that could take thousands or millions of years depending on conditions. A fast moving planet travelling at an oblique angle might just chip a bit off the edge of the other planet – and if it retains enough escape velocity, it would then just keep ongoing.

There's not that much difference in the physics of collisions between gas giants and between rocky planets. Head on collisions of planets of approximately equal size will result in a merger, although much debris will be produced – either gas or rocky debris. In either case, if it's flung out with enough force to achieve escape velocity it will be flung out, while other slower material may just go into orbit eventually to coalesce back into the newly merged planet or perhaps to form one or more moons. If one planet approaches the other at an oblique angle, there will be some mutual damage in the form of blown out rock or blown out gas, but less likelihood of a merger.

Observations of young stellar systems find evidence of multiple collisions which may causing mergers, but also produce huge amounts of debris, both rocky and gaseous. It's only as a system matures that a dominant object clears its orbit, of both planetesimals and finer debris and hence becomes a planet proper. So, all the previous narrative describes a number of unlikely scenarios. Once a large spherical body clears its orbit and adopts the proper definition of a planet, the chance of any further collision with something of equivalent size is pretty remote.

Looking around our own solar system, there's no likelihood of any planetary collisions in the foreseeable future. But, the only way explanation we have for Venus' incredibly-slow 243 day rotation in the wrong direction is a past collision. Uranus presumably received a big smack at some point in its history so that it now rotates on its side. And of course we're pretty sure a proto-Earth collided with something Mars-sized producing the Earth – Moon system we know today. The two rocky objects probably collided head-on – merging, but also throwing out huge chunks of debris which then coalesced into the Moon. That said it's equally possible there was something Mars-sized in Earth's orbit and something bigger collided with it – indeed probably neither had exactly Earth's orbit since the product of the collision would have gained a different mass and a slightly different orbital trajectory than either of its progenitors, so it's probably not meaningful to call one the collider and the other the collide – two things collided and the Earth-Moon system emerged from the rubble.

Both Jupiter and Saturn, though gas giants of predominantly hydrogen and helium, have higher levels of heavier elements than the Sun does suggesting they did not just grow out of the original dust cloud that the solar system formed from, but instead probably either merged with or just gobbled up other orbiting planetoids they encountered in their early lives, thereby ingesting already-concentrated packets of heavier elements. So proper planets rarely collide, but pre-planetary bodies do it all the time.

Question 2:

Dear Cheap Astronomy – Why is Mars sky red

A good place to start is to think about the colours we are familiar with in Earth's sky. In the middle of the day, the overhead Sun is a bright white disk you can't look at directly and the rest of the sky is blue.

This is because most of the visible light from the Sun passes straight through the atmosphere, which is transparent to those wavelengths, except at the very short end – so rather than passing straight through, photons in the blue and violet parts of the visible spectrum are scattered – meaning they are deflected off their straight line path and bounce around a lot, although most eventually reach the ground. Because of all that scattering, the whole atmosphere and hence the whole sky gets lit up blue. However, at sunrise and sunset the light has to travel a longer path through atmosphere before it reaches your eye, so all the blue is scattered away and the only light that does make it through to your eye is long wavelengths orange and red. The scattered blue light does still make it through, which is why if you look away from the sunset, the rest of the sky is still blue, but at sunset that blue is starting to dim and a few bright stars and planets start to shine through.

On the Moon, the Sun is that same painfully white disk, but the sky around it is just the black of space because there's no atmosphere so nothing to scatter light and nothing to reflect light off. You cast shadows on the Moon, just like you do on Earth, but a shadow on the Moon is pitch black, while on Earth shadows are just dark, because on Earth the lighting up of the whole atmosphere means some light is coming from all directions, not just direct from the Sun.

So now, let's think about Mars. It's got an atmosphere, but not much of an atmosphere with less than one per cent of Earth's atmospheric density at the surface. But what Mars atmosphere does have that Earth's generally doesn't have is dust. Earth can hold a lot of dust in its atmosphere – and when there is a lot of dust the sky goes red or brown or grey, but this generally doesn't last long because Earth's atmosphere also has water vapour in it, which will readily adhere to dust particles, sticking them together into clumps which become too heavy to remain airborne – and of course one solid downpour of rain will take all the dust out of the sky in a matter of minutes. But on dry, dusty Mars the dust just hangs in the air – and those large particles of dust don't scatter blue light, they absorb blue light completely – same goes for greens and yellows, only the longest wavelengths of visible light get reflected through – that is, the oranges, pinks and reds.

If you could take all the dust out of Mars sky, it would be blue, although because the atmosphere is so thin, it would be a very faint blue, because there isn't that much atmosphere to light up. But at sunrise and sunset, when the sunlight has to travel through a greater distance of atmosphere you start seeing a more intense blue. Put the dust back in and those dust particles are substantial enough to light up and hence give the sky a bright reddish colour. But at sunset, the longer light path through the atmosphere coupled with the more intense light coming directly from the Sun, means that just around the Sun's disk the atmosphere lights up just enough to overcome the reddish colour of the dust – and so on Mars you get a blue-hazed sunrises and sunsets.

The key physical principle is the dominant particle size – so with no atmosphere the sky is black, but with the dense but small particles of Earth's atmosphere, which includes ice crystals, the sky becomes a quite intense blue. But on Mars, the bigger atmospheric particles of dust are larger than the wavelength of blue light and so absorb blue and just reflect red. But calling it it pink or red is a bit of an over-simplification.

We know from rover photos that the Martian sky colour varies a lot depending on dust density and the elevation of the Sun and some of the photos are colour adjusted. We're pretty sure the average sky colour on Mars is actually a butterscotch - an orangey tan colour. And you probably get blue whispy clouds, which have a tiny amount of water crystals, not enough to give you the all-colour reflecting white of Earths clouds, but close to it.

So Mars' sky? Dusty, but potentially pretty. Well, maybe.